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REPORT OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

Note by the Secretary-General

1. The thirty-seventh report of the International Atomic Energy Agency for the calendar year 1992 (GC(XXXVII)/1060 is submitted herewith to the General Assembly. Major developments since this report was published will be covered by the annual statement of the Director General of the Agency to the General Assembly. This report has been transmitted in accordance with the provisions of article III, paragraph 1 (a), of the Agreement governing the relationship between the United Nations and the International Atomic Energy Agency (General Assembly resolution 1145 (XII), annex).

2. As only a limited number of copies of this report are available, it has not been possible to make a full distribution. Delegations are therefore requested to have the copies transmitted to them available during discussion of this item.

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THE ANNUAL REPORT FOR 1992

INTERNATIONAL ATOMIC ENERGY AGENCY

THE ANNUAL REPORT FOR 1992

GC(XXXVII)/1060

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INTERNATIONAL ATOMIC ENERGY AGENCY

Note

1. The draft Annual Report aims to summarize only the significant achievements of the Agency during the year in question. Details on the degree of completion of the individual tasks set out in the Agency's Programme and Budget for 1991 and 1992 and of monies spent can be found in the Programme and Budgetary Performance Report.

2. Certain experimental changes have been introduced this year to make the structure of the Annual Report follow even more closely that of the programme and budget document in terms of programmes, subprogrammes and projects. In particular, the subheadings used within the various sections are in most cases those of the projects shown in the programme and budget document. In addition, a "Programme Overview" has been added at the beginning of each chapter to give a general background and some information about changes that were introduced since the programme was originally formulated.

3. For the particular case of the chapter "Direction and Support", the combination of managerial, budgetary and service related activities does not lend itself to an approach that exactly follows the structure of the programme and budget document.

4. All sums of money are expressed in United States dollars.

5. The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

6. The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the Agency.

7. The term "non-nuclear-weapon State" is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the Treaty on the Non-Proliferation of Nuclear Weapons.

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INTRODUCTION

The **financial situation of the Agency**, which in 1991 had, for the first time, deteriorated to a point where adverse effects on a large number of activities could not be avoided, continued to be just as critical in 1992. Again, a cash shortfall caused by the failure of a large contributor to pay made it necessary to reduce the budgeted expenditures. A 13% cut was applied to all Departments. As of 31 December 1992, an amount of $30 million (or 15% of the total assessments for 1992) was still outstanding. In order to mitigate the adverse effect of the expenditure cuts, programme activities to a total equivalent of $16.2 million were deferred, to be implemented only if sufficient arrears in contributions were received, leaving a balance of $10 million in so-called 'forced budget savings'.

Implementation of activities equivalent to about $8 million deferred from 1991 was authorized in 1992 upon receipt of payment of arrears. At that time, about $1 million of deferred activities had become no longer necessary and were cancelled, but the possibility of implementing the balance of about $7 million compensated to a certain degree for the programme cuts in 1992 in terms of the overall level of activity for the year.

In June 1992, the Board of Governors considered the Secretariat's recommendation to transfer the administrative responsibility for the **International Centre for Theoretical Physics** (ICTP) from the Agency to UNESCO. As UNESCO welcomed the proposed transfer, representatives of the Agency, UNESCO and the Italian Government discussed its modalities at a number of meetings and prepared draft texts of a tripartite agreement and an amended agreement between the Agency and UNESCO concerning the joint operation of the ICTP.

The Board of Governors reviewed the arrangements for **the assessment of Member State contributions towards the safeguards component of the Agency's Regular Budget**. The General Conference, upon recommendation by the Board, approved arrangements for the financing of safeguards for each of the years 1993, 1994 and 1995 and requested the Board to continue to review these arrangements and to make a recommendation to it in 1995 at the latest. The General Conference also requested the informal working group to continue its work and to report to it, through the Board of Governors, at its thirty-seventh regular session.

As requested by the General Conference in 1991, the Board of Governors established, with no financial implications, an **informal working group on the financing of technical assistance**, with a view to advising the Board on ways and means to implement Resolution GC(XXV)/RES/388, in which the General Conference had requested the Board to take the necessary measures so that technical assistance was funded through predictable and assured resources. The General Conference, after having considered a report of the informal working group, requested the Board to re-establish the group, to remain seized of the matter and to report to it on the actions taken by it at its thirty-seventh regular session. The informal working group was re-established by the Board immediately after the thirty-sixth regular session of the General Conference.

The Board of Governors, as requested by the General Conference in 1991, re-established **an informal working group** open to all Member States **to examine different proposals on the revision of Article VI of the Statute** as a whole with a view to preparing a report to be submitted by the Board to the General Conference at its next session. The report of the informal working group showed that in the light of the wide range of views expressed during the discussions and of new worldwide developments, no comon ground had been found on the

substantive issue, the possible expansion of the membership of the Board. The General Conference requested the Board to establish a successor working group with the same mandate. This the Board did immediately after the 1992 regular session of the General Conference.

Pursuant to a decision taken by the Board of Governors in June 1991, ***the Bureau of the Committee on Assurances of Supply (CAS)*** *held further informal consultations with CAS members in 1992. The consultations centred on the supply and demand situation in the world nuclear power market. In June 1992, the Board agreed that such informal consultations should continue to be organized by the CAS Bureau, with an updated supply and demand paper to be prepared by the Secretariat, and that the Bureau should report back to it in June 1993.*

On the basis of a decision by the Board of Governors in February 1992, an open ended working group of legal and technical experts was established by the Director General with the task of carrying out the necessary substantive preparations for a ***nuclear safety convention.*** *At its two sessions, the expert group agreed that the objective was to achieve at an early date an 'incentive' convention based on peer group review to which a large number of States would adhere, and also discussed its content and structure.*

The question of ***liability for nuclear damage*** *continued to be a matter of priority. There was wide support in the Standing Committee on Liability for Nuclear Damage for focusing efforts on proposals for the revision of the Vienna Convention, as well as elaboration of a supplementary funding convention where good prospects for further progress existed. In order to facilitate the negotiating process, the Agency co-sponsored with OECD/NEA a symposium entitled "Nuclear Accidents — Liability and Guarantees", which was held in Helsinki in August–September.*

In September 1992, a review conference of the ***Convention on the Physical Protection of Nuclear Material****, convened by the Director General as depositary of the Convention, was held. At the conference it was affirmed that the Convention provides a sound basis for the physical protection of nuclear material during international transport and is acceptable in its current form.*

Feasibility and economic studies were carried out on the application of advanced reactors to the problem of ***desalination****, with reference to North African countries.*

Work was started on collecting and analysing previously unavailable information on ***uranium resources and production in eastern Europe and the former USSR.*** *The inclusion of these data in the new edition of the publication 'Uranium Resources, Production and Demand' (the "Red Book"), issued jointly with the OECD/NEA, brought this report closer to being a complete source of information on worldwide supply–demand projections to the year 2010.*

In December, the Director General convened a two-day meeting of experts from Member States involved in the ***international aspects of the plutonium cycle****. The discussion included reference to both civilian and military plutonium. At the meeting, the results were presented of an estimate of the worldwide inventory of plutonium in civilian nuclear programmes, made on the basis of information contained in the Agency's actinide and fuel cycle database and other available data.*

One result of the political changes in eastern Europe was the publicising of the significant ***environmental problems related to sites contaminated with radionuclides****. To facilitate the transfer of information on remediation activities, a technical co-operation project was initiated with the participation of 12 Member States from the region.*

Five manuals *were issued in the series of technical publications* ***on the management of low and intermediate level wastes*** *generated at small nuclear research centres and by radioisotope users in medicine, research and industry. These describe low cost solutions to relevant waste management problems.*

In the area of nuclear safety, the **International Nuclear Event Scale (INES)** moved from its test phase into systematic, routine application. A trial extension of the scale to types of nuclear facility other than nuclear power plants was started in March. At the end of the year, 49 Member States were co-operating in the use of the scale.

As a **follow-up to the Helsinki Symposium on 'Electricity and the Environment'**, a structure was developed for an interagency joint project on databases and methodologies for the comparative assessment of different energy sources, including their health and environmental impacts.

A major focus of activities under the **radiation protection** programme was the continued work on the development of new international Basic Safety Standards for protection against ionizing radiation and for the safety of radiation sources in the light of the 1990 Recommendations of the International Commission on Radiological Protection (ICRP).

The Agency continued to implement an extrabudgetary programme of **assistance to eastern Europe and States of the former USSR**. In the area of assessment of nuclear power plant safety, the Agency's efforts helped to achieve a consensus on technical safety issues for first generation WWER-440 Model 230 reactors. The Agency also initiated a project on RBMK reactors to review the technical basis for safety improvements. A programme dealing with the safety of the more modern WWER-1000 plants was established.

A prominent feature of the Agency's programme on nuclear applications was the attention given to **environmental protection problems**. Progress was made in demonstrating the potential of nuclear techniques in conservation of the environment through a series of meetings, consultants services and co-ordinated research programmes. The serious water resource and utilization problems in many developing countries underlined the importance of the support given to national institutions in connection with the application of nuclear techniques for assessing water resources and water pollution.

A variety of wheat which produces high yields under conditions of phosphate deficiency and low rainfall was discovered through isotope discrimination measurements.

A controlled release formulation of the herbicide thiobencarb was developed for use in rice paddies in which fish are produced. This formulation effectively controls grassy and broadleaf weeds, harms neither the rice nor the fish, and leaves no significant herbicide residues in the fish.

A banana cultivar with superior quality, yield and disease resistance was developed through mutation breeding at the Agency's Laboratory at Seibersdorf.

In connection with a General Conference resolution on introducing the practical use of **food irradiation** in developing countries, a new initiative was developed to facilitate the improvement of food safety, the reduction of storage losses and the easing of restrictions on international trade in foodstuffs.

An agreement on the **International Thermonuclear Experimental Reactor** Engineering Design Activities (ITER-EDA) was signed in Washington on 21 July by the four ITER parties — the European Atomic Energy Community (EURATOM), Japan, the Russian Federation and the United States of America — under the auspices of the Agency.

An **IAEA/WHO Interagency Consultation meeting** was held to discuss areas of collaboration. An **IAEA/UNEP/UNESCO Memorandum of Understanding** was signed to set out strategies for tripartite co-ordinated planning and implementation of activities on marine pollution by the **Marine Environment Laboratory (IAEA-MEL)**.

Among programmes of note carried out by the **IAEA-MEL** were the highly publicized assessment of the marine environmental consequences of pollution arising from the Gulf war

and the assistance given in the measurement and prediction of the effects of the recently announced dumping of highly radioactive materials in the Barents and Kara Seas. In addition, the Laboratory participated in an extensive experimental survey of nuclear and non-nuclear environmental contamination along the Danube river basin.

Notwithstanding an increase of $3 million in convertible currency pledges against the ***technical assistance and co-operation target****, the losses incurred as a result of the devaluation of a major non-convertible currency led to a decline in the overall value of resources. As a consequence, the percentage of the target met through pledges (which increased from 80.0% in 1991 to 81.1% in 1992 in respect of convertible currencies) showed an overall decline to 71.6% in 1992 when all currencies are included.*

The distribution of ***technical assistance*** *by Agency programme (or field of activity) remained characterized by an emphasis on disbursement for projects dealing with food and agriculture (18.3%) and physical and chemical sciences (19.0%). This latter field includes all activities pertaining to the maintenance and repair of nuclear instruments, which are basic to applications of nuclear technology in all other fields, as well as projects related to research reactor activities (including the production of radiopharmaceuticals and reagents).*

As far as the ***regional distribution of disbursed funds*** *is concerned, Africa for the first time received over $10 million. The share of Africa in the total approved programme has been steadily increasing over the past few years and is now the largest, standing at 26.1%. Asia accounted for 25.7%, Latin America for 21.4% and the Middle East and Europe for 18% of the programme. The remainder was allocated for interregional activities.*

Intensive discussions were initiated, aimed at a gradual ***redirection of the technical co-operation programme*** *towards increased emphasis on end user oriented projects and at ensuring that the links between technical co-operation projects and the overall development objectives of a country are further strengthened.*

Over 700 requests for the new ***two-year technical co-operation programme*** *for 1993-1994 were received and appraised. The resulting programming for the biennium includes a record number of over 500 new projects which could be made operational from available resources.*

China and France acceded to the ***Treaty on the Non-Proliferation of Nuclear Weapons*** *(NPT). All five nuclear-weapon States are now Parties to the Treaty. By the end of 1992, there were 149 non-nuclear-weapon States Parties to the Treaty, including several States which were part of the former USSR. As a result of the dissolution of the former USSR and the formation of a number of newly independent States, at the end of 1992 there were several States with significant nuclear activities but without any safeguards agreement. An action plan was prepared in readiness for the application of safeguards in the* ***newly independent States of the former USSR*** *and the first technical visits were undertaken to Kazakhstan, Lithuania and Ukraine. Fact-finding missions also visited Belarus, Kazakhstan and Ukraine.*

A safeguards agreement pursuant to the NPT entered into force in April with the ***Democratic People's Republic of Korea****. Inspection missions were performed in order to verify the correctness and assess the completeness of the State's initial report on nuclear material to be subject to Agency safeguards. The Agency concluded that it could not confirm the correctness and completeness of the initial report, and for this reason the Agency subsequently requested access to aditional information and sites.*

Following adoption by the General Conference in 1991 of Resolution GC(XXXV)/RES/567, the Agency undertook a programme of inspections to verify the correctness and assess the completeness of the initial report on the inventory of ***South Africa's*** *nuclear installations*

and material provided in accordance with the safeguards agreement conciuded pursuant to the NPT. The results of these inspections, reported to the General Conference in 1992, contained the interim conclusion that the verification activities had found no evidence that the list of facilities or the inventory of nuclear material, included in the initial report, was incomplete.

In response to General Conference Resolution GC(XXXV)/RES/559, a number of measures were proposed, discussed and approved by the Board of Governors for the ***strengthening of safeguards****. These measures included special inspections, early provision and use of design information, and reporting on the export and import of nuclear material and specified equipment and non-nuclear material.*

*On 28 April, Commissioner Cardoso e Cunha of the CEC and the Director General of the Agency signed a document entitled "****Effective and Efficient Implementation of Safeguards by the IAEA and EURATOM*** *under the Agreement (INFCIRC/193)". This document endorsed a new partnership approach on the implementation of safeguards in the European Community by the Agency and EURATOM under the provisions of the safeguards agreement between the European Community, its non-nuclear-weapon Member States and the Agency.*

During 1992, the Agency carried out 8 ***inspections in Iraq*** *(bringing the total number of inspections to 16 since May 1991) and implemented the essential elements of the plan for the destruction, removal or rendering harmless of the items indicated in United Nations Security Council Resolution 687, including the large Iraqi facilities at Al Atheer, Ash Sharqat and Tarmiya. One outstanding item was the removal of the high enriched uranium contained in the irradiated fuel elements of the Iraqi nuclear research reactors still stored in Iraq under Agency custody. Negotiations are continuing about the removal of this material, which is likely to take place in the course of 1993.*

In view of the Iraqi authorities' persistent refusal to disclose information related to foreign suppliers of equipment, material and technical advice used in activities prohibited under Security Council Resolution 687, the Agency has sought assistance from Member States to provide relevant information.

The Agency's inspections are also progressively phasing in elements of the future ongoing monitoring and verification plan of Iraq's compliance with Security Council Resolution 687. Among other measures, a radiometric survey of the main water bodies of Iraq was completed in the course of 1992 to obtain a baseline against which future measurements of the radioactivity level will be compared.

A significant event in 1992 in connection with ***computer utilization*** *in the Agency was the acquisition of the infrastructure upgrades approved by the Board of Governors in 1991. The new mainframe computers were installed in late 1991 and their operating system software was upgraded to the current standards in March. During the year, the first Departmental local area networks were installed. The introduction of additional telecommunications software and hardware enabled the shared mainframe computer to serve as a major node within the international scientific network INTERNET, which makes data available to Agency staff from computers in over one hundred countries. At the end of 1992, access to some Secretariat databases and internal electronic mail services was approved for the Vienna based missions.*

NUCLEAR POWER

Programme overview

The modest rate of growth in electricity demand in industrialized countries, the availability at the present time of relatively cheap coal and continued public hesitance about nuclear power were the reasons for the moderate increase in nuclear power capacity in 1992. Out of a total capacity of 6000 MW scheduled for connection to the grid in eight plants, 3778 MW(e), representing five nuclear power plants, became operational in 1992. However, the growing demand for dependable electricity and the increasing concern to reduce, or at least limit, the global level of fossil fuel combustion, point to the likelihood of an expanded use of nuclear power in the future.

There is an increasing trend by developing Member States to request more comprehensive assistance through an integrated package approach that can be used in nuclear power programme planning. A draft document on this subject is in preparation. However, the scale of development of computer packages and dissemination of information through seminars and workshops had to be kept at a modest level because of financial constraints. A newly introduced activity was the preparation of a document, at the request of developing Member States, on policy planning for nuclear power. It is anticipated that this document will be published in 1993.

During 1992, the Agency continued to document good practices that promote the achievement of better economic performance and a high level of operational safety. Thus, emphasis was placed on documenting the means by which some suppliers achieve better quality in construction work and shorter construction times, thereby attaining economic benefits from nuclear power plants constructed to high quality standards. During operation, achievement of good performance parameters is a crucial condition for ensuring that nuclear power can be seen as a viable option for long term electricity supply. As a result, nuclear power plant performance indicators were systematically monitored during 1992 and the PRIS database was expanded to include better worldwide coverage of operating experience, as well as an improved response capability.

Efforts were also concentrated on those areas that are significant for the attainment and maintenance of a high and stable level of operational safety. In this connection, work was co-ordinated to assess the effects of ageing on major plant components so as to assist understanding of the phenomena and provide data for making decisions in plant life management evaluations.

Since the quality of operation management is a central aspect of operational safety, manuals, review missions and training courses on the use of quality assurance methodology as an important management tool received particular attention and an integrated revision of the existing NUSS quality assurance Safety Guides was initiated.

Training requirements for operations personnel were documented and criteria for their accreditation developed. In particular, guidance was provided on the use of training simulators for improved staff proficiency and qualification. Technical documents were completed for control room design and the use of computers in design, operation and maintenance, along with techniques to improve quality assurance and validation for control system software in nuclear power plants. Considerable effort went into providing input for technical co-operation projects.

There has always been interest in expanding the use of nuclear power for other energy intensive uses besides electricity generation. In view of concerns over the emission of greenhouse gases from the burning of fossil fuel, investigations of other uses of nuclear heat are likely to be important in the future. High temperature heat applications for chemical processes was the subject of review and information exchange.

The worldwide availability of potable water exceeds substantially the amount of water being used. However, water resources are not evenly distributed. It is estimated that about three quarters of the world's population lack safe drinking water. Population growth, increased pollution and reduction of existing groundwater and surface water resources are expected to aggravate water supply problems, particularly in arid regions. In this connection, the Agency was requested by the General Conference (Resolutions GC(XXXIV)/RES/540 and GC(XXXV)/RES/563) to prepare a study on the technical and economic viability of using nuclear energy for producing fresh water. Substantial parts of the study have been completed.

In the area of nuclear fusion, the main topic dealt with in 1992 was lifetime predictions for fusion materials.

Some activities in the nuclear power programme, such as work on nuclear power plant ageing and life extension, the use of computers in design, operation and maintenance, and performance analysis of WWER reactors, were affected to a certain extent by reductions in the budget. This funding was partially restored later in the year, but came too late to facilitate full recovery. Consequently, these activities have been carried over into 1993.

Nuclear power planning and implementation

Development of an integrated package approach to energy, electricity and nuclear power programme planning

Agency methodologies (MAED, WASP, VALORAGUA and ENPEP) are widely used for energy, electricity and nuclear power planning. New developments include the following:

- A user's manual was published for two versions of VALORAGUA (for mainframe computers and personal computers);
- New releases of the various models were made available to several Member States;
- An updated version of WASP-III (WASP-III Plus) is under development and is expected to be completed in 1993;
- An updated version of the ENPEP package was completed in collaboration with the Argonne National Laboratory (USA) and work continued on the preparation of a user's manual for this new version, to be published by the Agency in 1993.

Several international organizations (e.g. the World Bank, the Asian Development Bank, the Inter-American Development Bank, CEC and OLADE) already use the planning models. Co-operative efforts with some of these organizations, initiated in 1991 and continuing in 1992, are expected to be completed in 1993. These include:

- The application of the ENPEP package in CEC regional studies;
- The use of certain models in the development by OLADE of a computer package for electricity expansion planning, adapted to the particular needs of the OLADE countries.

The main issues involved in the financing of nuclear projects, particularly in developing countries, were reviewed in order to provide basic information and guidance to Member States in planning the introduction of nuclear power as part of their electricity generation systems. A reference book on financing arrangements for nuclear power projects in developing countries was prepared; both the summary (in four languages) and the main report (in the Technical Reports Series) will be published early in 1993.

Assistance in nuclear power programme planning

In connection with the programme to provide support for developing Member States, especially for nuclear power programme planning and development, including energy and nuclear power planning studies, project feasibility studies, infrastructure development planning, manpower planning and project management:

- Support continued to be provided to China, Peru and Romania in conducting studies using the ENPEP package. These studies cover the following aspects for the countries mentioned: China: nuclear power economics and development plans; Peru: energy and power assessment programmes; Romania: energy demand forecasting and electricity expansion planning.
- Assistance was provided to Czechoslovakia, with support from Spain, for the preliminary evaluation of bids for the next nuclear power plant to be ordered.
- A case study on the feasibility of small and medium power reactors (SMPRs) in Egypt was completed, with the report to be published in 1993.
- Support continued to be provided to the National Atomic Energy Agency (BATAN) of Indonesia in training personnel in the discharge of the owner's functions associated with carrying out the feasibility study for its first nuclear power plant.

Good practices in nuclear power plant construction

Work progressed on a draft text intended to identify and document good practices in nuclear power plant construction in order to achieve shorter construction times, better quality and lower costs. It will be completed in early 1993.

General activities

The Energy and Economic Data Bank (EEDB) was updated using the latest information available from the United Nations Statistical Office, the World Bank, the Agency's PRIS database and other sources. In addition, work continued on the development of a local area network (LAN) based personal computer version (Micro-EEDB) to provide faster and easier access; the new version will be completed in 1993. Summary information from EEDB was published in the form of 'Country Tables'.

A review of nuclear power capacity and electricity generation projections was carried out in co-operation with other international organizations and with the assistance of consultants from Member States for publication in the Agency's Reference Data Series No. 1.

Use of computer models

	Number of releases of planning model or package			
	MAED	WASP	VALORAGUA	ENPEP
Member States	19	73	8	20
International organizations	4	6	—	2
Totals	23	79	8	22

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on integrated energy and electricity planning for nuclear power development, with emphasis on the ENPEP package	USA	37	8 weeks
Regional course on bidding, bid evaluation, contracting and financing of nuclear power plants	Spain	21	3 weeks
Regional course on electric system expansion planning	Pakistan	30	6 weeks
Workshop on energy economics and economic bid evaluation for nuclear power plants	China	25	2 weeks

Series and No.	Title
IAEA Yearbook 1992	Nuclear power, nuclear fuel cycle and waste management: Status and trends 1992
Reference Data Series No. 1	Energy, electricity and nuclear power estimates for the period up to 2010: July 1992 edition
Computer Manual Series No. 4	VALORAGUA, A model for the optimal operating strategy of mixed hydrothermal generating systems: User's manual for the mainframe computer version
Computer Manual Series No. 5	PC-VALORAGUA (version 1.00), user's guide: Microcomputer version of the VALORAGUA program for the optimal operating strategy of mixed hydrothermal generating systems
Special publication	Energy and economic tables, 1992 edition

Publications

Assessment and improvement of nuclear power plant performance

Analysis of nuclear power plant performance

With a view to providing information to Member States on the status and operating experience of nuclear power plants worldwide, performance indicators were monitored and the PRIS database maintained and updated. Information services continued to be provided to Member States by way of on-line access to PRIS: there were 64 users in 26 countries and 3 international organizations. A subset of the databank (MicroPRIS) was distributed to users, currently 147 in 50 Member States and 7 international organizations, including WANO, WISE, OECD, CEC, the Uranium Institute, WHO and UNSCEAR. For a more user-friendly interface, PRIS was redesigned and is being migrated to PC LANs. Improvements are also being introduced by expanding the database to include more information on plant sites and characteristics for, among other things, prompt use by the Agency's Emergency Response Unit. Co-operation with WEC and UNIPEDE continued, with participation in the Committee on Availability of Thermogenerating Plants, and work also continued on the promotion and harmonization of internationally compatible terminology and definitions.

Nuclear power plant ageing and life extension

In order to better understand the ageing mechanisms of main plant systems and components, the requirements for a material properties database and the methodology to be used as the main tools for life management assessments were identified. Three technical documents on these subjects were in preparation. A meeting of the International Working Group on Nuclear Power Plant Life Management (IWG-NPPLM) was held during which the Agency programme in this area for 1993–1994 was reviewed. Three specialists meetings on areas

Information on PRIS

	1986	1987	1988	1989	1990	1991	1992[a]
Participating Member States	30	31	31	32	32	31	34
PRIS on-line:							
Organizations in Member States using direct access	—	—	—	32	36	39	44
Member States using direct access	—	—	—	20	23	25	26
Direct access users	—	—	—	39	51	58	64
International organizations using direct access	—	—	—	1	2	3	3[b]
MicroPRIS							
MicroPRIS subscribers	—	—	—	—	—	110	147
International organizations using MicroPRIS	—	—	—	—	—	3[b]	7[c]
Member States using MicroPRIS	—	—	—	—	—	43	50
Power reactors in operation included in the system	330	389	408	426	423	420	423[d]
Reactor years of experience reported (cumulative values)	3411.3	3792.3	4194.3	5200	5622.9	6038.8	6462.5[d]
Data sets supplied on request	—	32	23	25	56	47	67

[a] As of 31 December 1992.
[b] OECD/NEA, WANO and WISE.
[c] CEC, OECD/NEA, UNSCEAR, the Uranium Institute, WANO, the WHO Regional Office for Europe and WISE.
[d] Estimates.

Nuclear power plant ageing and life extension (cont.)

related to the integrity of pressure retaining components were held and a CRP on optimizing reactor pressure vessel surveillance programmes neared completion. On the basis of the results from this CRP, a database on reactor pressure vessel surveillance is being developed.

Work continued, in co-operation with the OECD/NEA, on the economics and decision making aspects of nuclear power plant life management. A report on nuclear power plant life management approaches in OECD countries and some non-OECD countries (e.g. Czechoslovakia, India and the Republic of Korea) is planned for publication in late 1993.

Quality assurance programme management

The final draft of a technical document on nuclear power plant management, problems and solutions was completed. Work continued on the revision of the quality assurance Code and two related Safety Guides and progressed to the preparation of a second package, including five revised Safety Guides. In addition, a first draft for a new NUSS Safety Guide on quality assurance for research and development was produced. Quality management practices were promoted through active participation in international meetings and symposia and in the ASSET mission to the Kozloduy nuclear power plant in Bulgaria. Liaison was maintained with the CEC, ISO and FORATOM working groups.

Man-machine interface studies

The final drafts of two technical documents, one on computerization of the operation and maintenance of nuclear power plants and the other on guidelines for control room design, were completed. The exchange of information and experience was promoted by way of a symposium on nuclear power plant instrumentation and control, jointly organized with the OECD/NEA and held in Tokyo, and by two specialists meetings related to software engineering in nuclear plants and simulator training.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Optimizing reactor pressure vessel surveillance programmes	1994	16

CRPs established in the current year

Subject	No. of years	Participating institutions
Operator support systems in nuclear power plants	3	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Course on nuclear steam supply and turbine/generator inspection	Republic of Korea	27	2 weeks
Interregional course in nuclear power plant operation and maintenance	Czecho-slovakia	27	5 weeks
Interregional course on qualification of nuclear power plant operating personnel	Germany	23	4 weeks
Workshop on management control of quality during construction and operation of nuclear power plants	Mexico	23	1 week
Workshop on management control of quality in the maintenance of equipment and operative systems	Brazil	27	1 week
Workshop on quality assurance during nuclear power plant construction	Czecho-slovakia	20	1 week
Workshop on the role of utility management in achieving safety culture	Romania	30	2 weeks

Publications

Series and No.	Title
Annual publication	Operating experience with nuclear power stations in Member States in 1991
Reference Data Series No. 2	Nuclear power reactors in the world: April 1992 edition
Technical Reports Series No. 340	Quality assurance integrated training packages: A manual
IAEA-TECDOC-668	The role of automation and humans in nuclear power plants

Improvement of reactor technologies

Innovative designs and technology improvements in water cooled reactors

A Technical Committee meeting on the significance of design and operational margins considered the use of margins in some Member States. It was apparent that there were still difficulties in developing a definition that covers all aspects of the term 'margin'. The reasons for creating margins for advanced water reactors were identified as being to: introduce conservatism; provide operational flexibility; accommodate uncertainties; and cope with regulatory requirements in all aspects.

Reactor systems for improved resource utilization

At its 25th annual meeting, the International Working Group on Fast Reactors (IWGFR) reviewed the status and current trends in national and international LMFR development programmes.

- Members of the IWGFR reviewed the status of fast breeder reactor development programmes in Member States, defined and agreed on topics for specialists meetings to be organized in 1993, and considered the CRPs currently in progress and international conferences for the period 1992-1995.
- Phase 1 of the European Fast Reactor (EFR) design is devoted to the concept design; phase 2, concept validation, will run until March 1993.
- In China, the development of FBR technology was pursued from 1987 until the present time under the framework of the State High Technology Programme. The State Council authorized the First Fast Reactor (FFR) project, which comprises a 65 MW(th) and 25 MW(e) experimental fast reactor.
- Design of prototype fast breeder reactors in India is progressing.
- In Japan, the 'Joyo' experimental reactor, located in the Oarai Engineering Center of the Power Reactor and Nuclear Fuel Development Corporation, has provided abundant experimental data, attaining a total of 43 500 hours of operation by the end of 1991 since its first criticality in 1977. Construction work on the prototype Monju reactor was completed and functional tests are in progress. The Japan Atomic Power Company is promoting design studies of demonstration fast breeder reactors (DFBRs) under contracts with several leading Japanese manufacturers for selection of the basic specifications of the DFBR.
- Three fast reactors are in operation in Russia and one is in operation in Kazakhstan.
- The prototype fast reactor programme in the United Kingdom may continue to be funded by the Government until March 1994.
- A key strategy within the Advanced Liquid Metal Reactor (ALMR) programme in the USA is to evaluate the potential of metal fuel based on the integral fast reactor (IFR) concept developed at Argonne National Laboratory. The technology supports practical actinide recycling. The metal fuel cycle is designed to recycle and burn its own minor actinides and has the potential to be a very effective utilizer of the Pu and minor actinides generated in LWRs. The entire ALMR system can thus extend uranium resources by a hundredfold, making nuclear energy essentially the same as a renewable energy source.

Reactor systems for improved resource utilization (cont.)

In the framework of the technical information exchange activities of the IWGFR, a specialists meeting on the use of fast breeder reactors for actinide transmutation was held in Obninsk, the Russian Federation. The meeting highlighted the increasing interest in long lived radioactive nuclides and aspects of toxicity in nuclear waste management, and the desirability of developing a co-ordinated approach to their solution. Also discussed was the potential of fast reactors for reducing the long term radiotoxicity of spent fuel.

An essential aspect of fast reactor safety is the problem of sodium void reactivity. Studies conducted recently in Russia have indicated the potential of reducing this value to zero by the introduction of a sodium plenum above the core instead of the upper axial blanket. At a specialists meeting on passive and active safety features of LMFRs, held at the Oarai Engineering Center, Japan, it was recommended that the Agency arrange for an appropriate exchange of specialists to discuss the results of the calculations from the mathematical model prepared by Russia under the auspices of the IWGFR. In order to broaden the international base of this work and to share the projected expenses, it was agreed to organize this work jointly with the CEC. It was shown that the overall sodium void effect of the benchmark core with its specified properties is close to zero and that it might even be slightly negative if the negative heterogeneity correction is taken into account. A summary report will be available in 1993.

Core design and management

Final Research Co-ordination meetings were held for a CRP on in-core fuel management code package validation for LWRs and for a similar CRP on HWRs. Benchmark calculations from the CRP participants were reviewed, discussed and tabulated in a consistent format. The calculation results for the PWRs were in reasonable accordance with the measured data; the draft report was completed and submitted for publication. Outlines for the reports on BWRs, WWERs and HWRs have been prepared.

A Technical Committee meeting on in-core fuel management focusing on reloading techniques was held in Vienna in October. The objective of the meeting was to provide an international forum for nuclear engineers and physicists from Member States to present, review and discuss in-core fuel management reloading techniques of LWRs. There was also a presentation on the latest reloading techniques. During a follow-up workshop, three topics, i.e. optimization techniques, expert system codes and the number of energy groups used in reactor calculations, were discussed.

Progress was made in a CRP on safe core management with burnable absorbers in WWERs. An additional benchmark for experimental investigations performed at the Rheinsberg nuclear power plant was selected for further calculations.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	In-core fuel management code package validation for LWRs	1992	16
1988	Safe core management with burnable absorbers in WWERs	1992	9
1989	Acoustic signal processing for the detection of boiling or sodium water reactions in LMFBRs	1992	7
1989	Benchmark for in-core fuel management programs for HWRs	1993	7
1990	Establishment of a thermophysical properties database for light and heavy water reactor materials	1994	6
1991	Intercomparison of LMFBR seismic analysis codes	1994	7

Publications

Series and No.	Title
IAEA-TECDOC-638	Technical aspects of high converter reactors
IAEA-TECDOC-665	Materials for advanced water cooled reactors
IAEA-TECDOC-677	Progress in development and design aspects of advanced water cooled reactors
IAEA-TECDOC-678	Enhanced calculational methods for power reactors and LWR core design parameters

Development of advanced reactor systems

Future design concepts

A Technical Committee meeting and workshop were held to finalize a document on objectives for the improvements being developed for advanced nuclear plants. The preparation of this document was initiated in 1990 in response to a recommendation that the Agency should become more involved in establishing internationally agreed upon requirements regarding the development of advanced nuclear power plants.

At a Technical Committee meeting in Aix-en-Provence, France, on advanced containment technologies, the following topics and problems were identified and discussed: development trends in containment designs; severe accidents and associated physical phenomena; the role of active and passive systems in advanced containments; engineering solutions to cope with the probability of severe accidents involving advanced light water reactors; and theoretical and experimental investigation and testing models. A status report on advanced containment technologies, to be published in 1993, will be oriented mainly towards aspects of advanced water cooled reactors.

Nuclear heat applications

A specialists meeting was organized to provide a comprehensive review and opportunity for discussion of decay heat removal and heat transfer under normal and accident conditions in gas cooled reactors. The meeting was hosted by the KFA Research Centre, Jülich, Germany. Advanced gas cooled reactor (AGR) designs currently under development are predicted to achieve a high degree of safety through reliance on passive systems for heat removal during accidents. Data were discussed in detail from experiments performed in Japan and Germany on specific heat transport phenomena. Experience in heat transport under actual reactor conditions has been obtained in Magnox and AGR reactors in the United Kingdom and France and in HTGRs in Germany and the USA. A key conclusion was that the predicted performance of passive systems needs to be proved under experimental conditions representing realistic reactor situations prior to the licensing and commercial deployment of AGRs.

This meeting also provided important information for a new CRP on heat transport and afterheat removal for gas cooled reactors under accident conditions. It was recommended that the objective of the international co-operation should be to establish sufficient experimental data and validation of analytical tools to confirm the predicted safe thermal response of AGRs during accidents. Such co-operation would be useful for the ultimate goal of supporting licensing efforts for future plants.

A Technical Committee meeting and workshop on high temperature applications of nuclear energy was held at the Oarai Research Establishment of the Japan Atomic Energy Research Institute (JAERI). It was recommended that a CRP be established on the design and evaluation of the high temperature test reactor (HTTR) heat utilization system. The objective of the CRP would be to establish a conceptual design for the HTTR heat utilization system by developing and evaluating candidate systems which effectively utilize high, medium and low temperature heat by heat cascading. Participants will propose candidate systems on the basis of their country's interests and suggest methods on combining the high, medium and low temperature systems. They will also prepare draft safety design guidelines.

Nuclear heat applications (cont.)

A third Research Co-ordination meeting for a CRP on the validation of safety related physics calculations for low enriched gas cooled reactors was held at the Paul Scherrer Institute, Switzerland, to discuss the status and needs of the Proteus critical experiment. First criticality at Proteus was achieved on 7 July. In this CRP, experience from the Russian Federation's ASTRA and GROG critical experiment programmes is being utilized. Also, temperature coefficient data from the VHTRC critical experiments at JAERI were provided to participants and used for code validation. Reactor physics measurements are under way on the first core. The reactivity worth of the control rods was determined. Axial neutron flux distributions in the core centre and in the side reflector were determined using ^{235}U, ^{239}Pu and ^{241}Pu miniature fission chambers. Preparations are under way for experiments to determine the effects of moisture ingress on core reactivity and control rod worth.

Application of advanced technologies

In response to General Conference Resolutions GC(XXXIV)/RES/540 and GC(XXXV)/RES/563, the technical and economic aspects of potable water production through the desalination of sea water using nuclear energy and other means were evaluated and a report prepared and published. The report contains an assessment of the need for desalination and information on the most promising desalination processes and energy sources and on nuclear reactor systems proposed by potential suppliers worldwide. The main part of the report is devoted to evaluating the economic viability of seawater desalination using nuclear energy as compared with fossil fuels. Relevant safety and institutional aspects are also discussed. The overall conclusion was that the use of nuclear energy is technically competitive for medium to large size units integrated into the electricity grid system. Large nuclear plants integrated into the grid and supplying electricity to separately located desalination plants using reverse osmosis offer the most cost advantageous option.

In addition to the general study mentioned above, the Agency, at the request of five Member States in North Africa, provided technical assistance to a regional feasibility study on the use of nuclear energy for seawater desalination. Several meetings were held, relevant information was gathered and the drafting of a report was initiated.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Validation of safety related physics calculations for low enriched gas cooled reactors	1995	7

CRPs established in the current year

Subject	No. of years	Participating institutions
Validation of prediction methods for thermal and fission product behaviour in gas cooled reactors	3	7
Heat transfer and afterheat removal under accident conditions	3	7

Publications

Series and No.	Title
IWGGCR/27	Tenth meeting of the International Working Group on Gas Cooled Reactors
IAEA-TECDOC-666	Technical and economic evaluation of potable water production through desalination of seawater by using nuclear energy and other means

Nuclear fusion

Fusion research and engineering

The 3rd Research Co-ordination meeting for a CRP on lifetime predictions for the first wall of fusion machines was held in September 1992. The objective of this CRP is to validate existing tools used for predicting the lifetime of first wall components. A benchmark analysis and companion experiment involving a defect free first wall component was completed. The first wall component underwent testing at the Thermal Cycling Test Facility at the Joint Research Centre (JRC), Ispra. Evaluation of the lifetime predictions highlighted differences in methodology among the participating institutes for producing both design allowable and realistic estimates of lifetime and resulted in recommendations of the preferred methods. The JRC test results yielded lifetimes in excess of the design allowable predictions of all participants with sufficient margin. Agreement was reached on the details of a benchmark exercise and companion experiment investigating the influence of defects (fabrication defects, brazing defects, or defects introduced by plasma disruption) on the first wall lifetime under thermal cycling conditions. The related experimental work on flawed specimens is being conducted at the JRC under the European Fusion Technology Programme.

A document on the status of fission/fusion hybrids was cancelled on the recommendation of the International Fusion Research Council.

The 14th Conference on Plasma Physics and Controlled Nuclear Fusion Research was held in Würzburg, Germany, in September–October. Two hundred and six technical papers and five summary papers were presented, reflecting steady progress in magnetic and inertial fusion research. Encouraging results were obtained in large tokamaks. All large tokamaks carried out an experimental programme on non-inductive current drive aimed at steady state operation. Though the status of current stellarators lags behind tokamak experiments by two machine generations (based on a comparison of machine sizes), significant results were reported from experiments carried out in Germany, Japan and the USA. Since the last conference, the inertial confinement fusion concept has made progress on four major physics issues: driver–target coupling, irradiation uniformity, hydrodynamic pellet stability and fuel conditioning.

The Agency received a proposal from the Atomic Energy Authority of Egypt to co-operate in establishing a plasma physics training centre for developing countries. The proposed site is the Nuclear Research Centre, Cairo. Consideration of this proposal is continuing.

A CRP on development of plasma heating and diagnostic systems in institutes in developing countries using middle and small scale plasma devices was approved. The purpose of this CRP is to co-operate with individual fusion programmes in developing Member States in order to maximize the scientific and technological gain of fusion research, to strengthen scientific links between fusion laboratories in developed and developing countries and to involve fusion groups in developing Member States in mainstream fusion research.

Technical Committee meetings on advances in the simulation and modelling of thermonuclear plasmas and on tokamak plasma biasing were held in Montreal, Canada. Summaries of these meetings will be published in the *Nuclear Fusion* journal and the *Fusion Technology* journal, respectively.

Nuclear Fusion journal

Twelve regular issues of *Nuclear Fusion* were published, comprising 134 articles, 48 letters and 15 conference reports. Of particular importance were the special topic 'Global energy confinement H-mode database for ITER' and the first results of the JET deuterium–tritium experiments.

The second and third volumes of the series *Atomic and Plasma–Material Interaction Data for Fusion* were published as supplements to *Nuclear Fusion*.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Lifetime predictions for the first wall of fusion machines	1994	5

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of plasma heating and diagnostic systems in institutes in developing countries using middle and small scale plasma devices	5	8
Development of software for numerical simulation and data processing in fusion energy research	3	4

Publications

Series and No.	Title
Proceedings Series	Plasma physics and controlled nuclear fusion research 1990
Supplement	Atomic and plasma–material interaction data for fusion, Vols 2 and 3
ITER EDA Documentation Series No. 1	ITER EDA agreement and protocol 1
ITER Documentation Series No. 34	ITER assembly and maintenance
ITER Documentation Series No. 35	ITER plant systems
ITER Documentation Series No. 36	ITER safety

NUCLEAR FUEL CYCLE

Programme overview

The aims of the nuclear fuel cycle programme are to help enhance the safety, reliability and economics and to minimize the environmental and health impacts of nuclear fuel cycle activities in Member States. During 1992, the aims were achieved through information exchange, preparation of databases and safety related publications, and promotion of CRPs and technical co-operation projects.

Efforts in the area of raw materials were focused on collecting and analysing previously unavailable information on uranium resources and production in eastern Europe and the area of the former USSR. Part of the data has been incorporated into the new 'Red Book'. The long standing co-operation with OECD/NEA in relation to the Uranium Group was modified to accommodate the participation of non-OECD countries which are Member States of the Agency.

The emphasis in the area of uranium mining and milling was shifted to the examination of environmental impacts, regulatory aspects and economics.

Two activities not described in the 1991–1992 programme were initiated, reflecting new situations that had arisen: an examination of the impact of the new ICRP recommendations on uranium production costs and work on the management of earth science data on personal computers.

The new activity relating to the Agency's actinide and fuel cycle database, initiated in 1991, was continued.

The worldwide inventory of plutonium in civilian nuclear programmes was estimated from information in the actinide and fuel cycle database and other available sources. The results were presented at a meeting convened by the Director General in December.

In relation to long term spent fuel storage, the preparation of Safety Series documents proceeded as scheduled, with publication planned for 1994. Advisory missions on the long term storage of spent fuel from nuclear power reactors, research and/or test reactors were conducted in Hungary and Ukraine. On the basis of the experience gained, the service will be offered regularly for the period 1993–1994 and beyond under a technical co-operation programme.

Concern about the management of spent fuel from research and test reactors is mounting rapidly owing to the age of these reactors and also to difficulties encountered in returning spent fuel for reprocessing. A programme has been started to address this crucial area.

In order to avoid duplication of efforts with other international organizations, programmes relating to the economics of the fuel cycle were discontinued.

Raw materials for reactor fuels

Assessment of uranium resources, supply and demand

As part of the programme to maintain and improve the quality and coverage of supply and demand estimates relating to world nuclear fuel resources, relevant analyses were performed on the status of the uranium industry and its likely future development.

Uranium production in 1992 in the former WOCA declined by about 4500 t to 23 500 t in response to continuing unfavourable market conditions. Nine countries produce nearly 95% of the total, and eight countries contribute the remaining 5%. The reactor related uranium requirements in 1992 are about 46 500 t. The resulting underproduction amounted to approximately 23 500 t, which is covered by material held in stocks and inventories in WOCA as well as by imports from China and the former USSR.

The world uranium supply–demand situation, which for 1992 is known only with some degree of uncertainty, shows features similar to those given above. Uranium production in 1992 was about 37 000 t, with Canada, Kazakhstan, Russia, the USA and Uzbekistan as the leading producer countries with a combined share of over 55% of the world total. The reactor related uranium requirements are believed to be 57 000 t worldwide, which is about 20 000 t above the world uranium production.

Up to the year 2010, the low cost supply of uranium based upon the expected production from former WOCA producer countries is projected to be around 25 000 t, while the uranium requirements for this region are expected to grow to 57 000 t. This estimated production gap, which will reach nearly 40 000 t in 2010 and cumulatively about 350 000 t, may be partly filled by WOCA stocks and imports, but will require production centres in addition to those which are currently existing and committed.

A new edition ('Mini-Red Book') of the joint report of the Agency and the OECD/NEA on Uranium Resources, Production and Demand (the 'Red Book') was issued near the end of the year. Significant data received from Member States not traditionally providing the relevant information (the former USSR, the former German Democratic Republic and Romania in particular) have made the present issue closer to being a complete and authoritative source of worldwide information and supply–demand projections to the year 2010.

The potential impact on some uranium producers of the latest recommendation of the ICRP (ICRP 60) to reduce the overall occupational dose limit by 60% from 50 mSv/a to 20 mSv/a was assessed by a group of consultants. It was concluded that underground mining, especially of high grade deposits, and some enclosed ore processing plants could be affected by application of the ICRP 60 recomendations. However, it is believed that technical solutions will be found to enable the industry to meet the requirements in some cases. These measures may require additional resources, which in the current depressed uranium market situation may have a negative influence on the viability of certain projects.

Development of a standardized approach

The preparation of a publication on spatial data integration for mineral resource assessment and environmental studies continued and is expected to be completed by the early part of 1993. The main objective will be to promote the use of the Geographical Information System (GIS) in the integration and management of different types (layers) of information for natural resource assessment and environmental studies.

Development of a standardized approach (cont.)

A completed document containing guidelines for the organization and management of earth science data on a personal computer is part of an effort to encourage developing countries to manage the enormous amount of data collected during past mineral exploration and development programmes. A properly managed database system will facilitate exploitation of this invaluable information for the mineral resource inventory of the country and the preparation of baseline information for environmental monitoring.

As a result of its competitive cost and proven environmentally sound technology, the relative importance of in situ leaching of uranium exploitation has grown considerably since the mid-1970s. Approximately 16% of the world uranium production was produced by in situ leaching methods in 1991; of this, 14% came from eastern Europe, central Asia and China. This share is expected to increase. In this connection a Technical Committee meeting on uranium in situ leaching was held in October. The technical papers covered the different methods of in situ leaching, its effect on the environment, groundwater restoration and related regulations. Reports from Bulgaria, China, Czechoslovakia, Germany (from the operation in the former German Democratic Republic), Russia and Uzbekistan represented new information in this field and were therefore of particular interest. The proceedings of the meeting will be issued in 1993.

A meeting to finalize a document on steps for preparing uranium production feasibility studies was held. This document stresses the importance of systematic economic analyses of a uranium exploration and production project from the early stages of the programme, an important approach not normally practised by countries which recently shifted to a market economy system. It is planned to issue the report as an IAEA-TECDOC in 1993.

Preparation of a guidebook on regulations for uranium deposit development and production was initiated in 1992. The first draft of the report is expected to be completed during the second half of 1993. The report is aimed primarily at countries which do not have well developed regulations related to the various stages of exploration, development, production and eventual closure.

Preservation of uranium geology and exploration data

The preparation of a world map of uranium deposits continued, with a third consultants meeting which reviewed the newly received information submitted from a number of countries. After a review of existing world geological maps for their possible use as a basis for the atlas, it was found to be necessary to produce a simplified map. This task, to be carried out by Russian specialists, will be completed in mid-1993.

Training courses and seminars held

Course name	Location	No. of participants	Duration
National course on geology and exploration of sandstone and igneous type of uranium deposits	Pakistan	30	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 341	Analytical techniques in uranium exploration and ore processing
Technical Reports Series No. 344	Methods for the estimation and economic evaluation of undiscovered uranium endowment and resources: An instruction manual
IAEA-TECDOC-650	New developments in uranium exploration, resources, production and demand

Reactor fuel technology and performance

Safe technology and utilization

A Technical Committee meeting on fuel failure was held in Dimitrovgrad, Russia. A significant number of the presentations were analyses of fuel failure over a substantial period of time (5–7 years). The statistics showed that in spite of the increasing demands placed upon fuel in LWRs during recent years, for example higher burnups, load following and increased cycle periods, the rate of fuel failure has continued to fall. The reduction in failure rates is a result of the effectiveness of the countermeasures introduced.

The three first volumes of the WACOLIN (CRP on water chemistry control and coolant interactions with fuel and primary circuit materials in water cooled reactors) publication have been issued in the IAEA-TECDOC Series and the overview report on coolant technology of water cooled reactors, published in the Technical Reports Series, will be issued in January 1993.

A CRP on examination and documentation methodology for water cooled reactor fuel (ED-WARF-II) was started. The objective is to provide an exchange of information on important aspects of post-irradiation examination (PIE): hot cell facilities, hot cell examination techniques, special PIE techniques and data acquisition and documentation methodology. The first Research Co-ordination meeting on ED-WARF-II took place in Řež, Czechoslovakia.

The final draft of a report on the decontamination of water cooled reactors has been reviewed and is ready for publication. It was first foreseen to publish this document in the IAEA-TECDOC Series. However, since it will probably serve as a reference document, the possibility of issuing it in the Technical Reports Series is now being considered.

The 11th plenary meeting of the International Working Group on Water Reactor Fuel Performance and Technology (IWGFPT) was held in Vienna. The programmes of the Agency in this area were reviewed. Special attention was given to avoiding overlap and redundancies.

A Technical Committee meeting on the behaviour of core materials and fission product release in accident conditions in LWRs was held in Cadarache, France. A wide range of topics was covered: fuel behaviour in LOCA conditions; reactivity insertion accidents; fuel behaviour in several fuel damage conditions; and fission product release. There are many indications of a move from extensive thermohydraulic LOCA type of studies towards severe accident conditions, with two main tendencies: an increase of interest in reactivity accidents; and concern with the consequences of high burnup fuels on the different phenomena involved in an accident.

In accordance with recommendations made in 1986, in-pile tests on high burnup fuel have been accomplished under LOCA conditions and have shown greater fission product release and fuel degradation. A new duplex cladding has been developed, combining the mechanical properties of Zr-4 with the corrosion resistance of a special alloy outer layer and providing improved behaviour during normal operation. The data available for standard Zircaloy should be extended to other alloys, including Zr–Nb, for high temperature transient behaviour.

A Technical Committee meeting on fission gas release and fuel rod chemistry related to extended burnup was held in Pembroke, Canada. The meeting recorded the progress made in the evaluation of fuel temperatures, degradation

Safety technology and utilization (cont.)

of the global thermal conductivity with burnup and understanding of the impact on fission gas release. However, there is a need to explore further the area of even higher burnup fuel with realistic linear power rates and histories and to accumulate additional macroscopic observations and improved mechanistic understanding of fission gas release associated with the thermal behaviour of the fuel and burnup. It was stressed that MOX fuel should be studied in the same way as UO_2 fuel to confirm similarities and differences in behaviour.

A Technical Committee meeting on in-core instrumentation and in situ measurements was hosted by the CEC and held in Petten, Netherlands. Instrumentation and methods for in-core and in situ measurements, refabrication and reinstrumentation techniques in material test reactors were reviewed. For power reactors, on-line systems, monitoring systems and methods for evaluation of core parameters related to fuel behaviour were also discussed. It was found that although the instrumentation used in irradiation experiments is satisfactory, further developments are desirable, for instance to minimize drift and the need for recalibration. New developments are also needed to measure parameters such as cladding hydriding, high temperatures in hostile environments, direct fission gas release or accurate linear power. In power reactors efforts are still needed to assess operational limits by developing adequate instrumentation and core modelling. In turn, better modelling and a better understanding of the phenomena involved are needed to reduce uncertainties.

A comprehensive review of the corrosion mechanism of zirconium based alloys in the environments found in nuclear power plants has been prepared for publication as an IAEA-TECDOC. This should be available early in 1993.

The main task in connection with the Agency's actinide and fuel cycle database has been to include the parameters needed for spent fuel, fuel fabrication, enrichment services and natural uranium and plutonium calculations. Some benchmarking was satisfactorily performed. The next steps will be to adapt a module for actinide calculation and to benchmark the code. By using the results of the calculation on the amount of plutonium in spent fuel and other relevant data, the inventory of plutonium in civilian nuclear programmes in the world was estimated.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Burnable absorber for LWR fuel (BAF)	1994	9

CRPs established in the current year

Subject	No. of years	Participating institutions
Examination and documentation methodology for water cooled reactor fuel (ED-WARF-II)	4	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
QA/QC in water reactor fuel development and manufacturing	France	28	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 343	Water reactor fuel extended burnup study
IAEA-TECDOC-667	Coolant technology of water cooled reactors: Volume 1. Chemistry of the primary coolant in water cooled reactors Volume 2. Corrosion in the primary coolant systems of water cooled reactors Volume 3. Activity transport mechanisms in water cooled reactors

Spent fuel management, technology and safety

Spent nuclear fuel arisings and storage capacity requirements

Consultants from France, Germany, the United Kingdom and the USA prepared a draft of a publication on strategies, options and trends in spent fuel management. The document presents the options and choices which are available for the management of spent nuclear fuel, and enables Member States to achieve an integrated approach to spent fuel management by addressing the important considerations in a structured manner. The Technical Reports Series publication will be finalized in 1993.

During an Advisory Group meeting on spent fuel documentation, inventories and projections, participants compiled a spent fuel management database and evaluated a set of information parameters needed to ensure the safe and reliable handling of spent fuel. The group reviewed status reports on spent fuel inventories, their projections and related documentation. It identified the main categories of data requirements relating to each of the back end stages of the fuel cycle, including handling and transport.

Spent fuel storage options and practices

On the basis of the results of an Advisory Group meeting, a draft was prepared of a manual on design, technology and operational experience. The main goal of this publication is to provide specialists with new information and international experience on how to achieve technical requirements for spent fuel storage facilities, with examples based on the experience of different countries.

Degradation of the mechanical and physical properties of ageing materials in irradiated fuel storage facilities is beginning to raise serious concerns. In particular, the lack of understanding of the fundamental mechanisms of material response to the corrosive environments found in irradiated fuel storage facilities raises a formidable barrier to the prediction of behaviour over extended time periods. This inability to extrapolate with any confidence the behaviour of materials in ageing storage facilities causes concerns about the long term integrity of the facilities and may lead to problems in securing licence extensions beyond the original design life. Nevertheless, applications for licence extensions well beyond the original design life will be prompted by the decision in some countries (such as the USA) to phase out fuel reprocessing and by the delays in almost all countries in the production of final disposal facilities. To address these concerns the first steps have been taken to establish a CRP on the irradiation degradation of materials in spent fuel storage facilities.

Irradiated fuel management (IFMAP) service and advisory missions

A consultants meeting was held to discuss the initiation of irradiated fuel management (IFMAP) services. The goal of the project is to assist developing countries in questions related to the safe storage and management of fuel from both research and power reactors. A pamphlet was prepared to inform interested Member States about the project.

At the request of the Hungarian Atomic Energy Commission, a mission was organized to Hungary to advise the Paks Nuclear Power Plant operators on the methods and available technologies of safe spent fuel storage. Up to date information was provided to the operators and to the representatives of different regulatory agencies.

At the request of the Ukrainian State Committee on Nuclear and Radiation Safety, a fact finding mission took place to discuss among other issues the problems associated with the management of spent fuel in Ukraine.

Spent fuel treatment and recycling

An Advisory Group meeting on spent fuel treatment was held with the objective of reviewing the status and trends of spent fuel treatment. Country reports were presented and the main areas of current development in spent fuel reprocessing were discussed.

Experts from Belgium, France, Japan, Russia and the CEC reviewed the status of development in Member States in the field of partitioning and transmutation (P&T). The existence of programmes by OECD/NEA and CEC had led the Agency to establish a complementary study on the fundamental safety aspects of P&T that could be beneficial in assisting Member States in their national programmes and fostering information exchange. It was recommended that the Agency undertake a study with the emphasis on the environmental and non-proliferation implications of P&T.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1991	Behaviour of spent fuel assemblies and storage equipment under long term storage conditions (BEFAST-III)	1995	17

Publications

Series and No.	Title
IAEA-TECDOC-673	Extended storage of spent nuclear fuel
IAEA-TECDOC-679	Consolidation of spent fuel rods from LWRs

RADIOACTIVE WASTE MANAGEMENT

Programme overview

The restructuring of the radioactive waste management programme, started in early 1991 to ensure that activities more closely met the needs of Member States, was completed in 1992. Implementation strategies for the year reflected the increased awareness in countries that generate nuclear wastes only from non-fuel-cycle applications of the need to couple the uses of such applications with a national waste management system. The programme also reflects increased recognition of the need to demonstrate international consensus in approaches to the safe management of radioactive wastes.

The main areas of focus for the programme in 1992 included:

- *Development and implementation of the Radioactive Waste Safety Standards (RADWASS) programme;*
- *Strengthening of the waste management infrastructure in countries where waste arises from the use of radioactive materials;*
- *Collection and distribution of technical information on the handling, processing and disposal of radioactive waste generated from nuclear applications.*

Other areas receiving major emphasis included the strengthening of the capabilities of Member States in the technical and regulatory aspects of the decommissioning of nuclear facilities (including research reactors and uranium mining and milling plants), in the assessment of the radiological and environmental impacts of waste disposal and in quality assurance methodologies for waste packages and disposal systems.

Significant progress was achieved in the RADWASS programme through a series of consultants and Technical Committee meetings held to draft and review the highest priority documents, including the Waste Management Safety Fundamentals and four Safety Standards. In consideration of the urgency of this programme, steps were taken to ensure that the target of nine RADWASS publications to be completed in the Phase I period (1991–1994) would be met. A significant milestone was achieved with the publication of the first book in the RADWASS series, a Safety Practice, Application of Exemption Principles to the Recycle and Reuse of Materials from Nuclear Facilities.

An awareness of the need to provide assistance in strengthening waste management infrastructures in Member States which generate waste from nuclear application activities has been clearly demonstrated through missions carried out under the Radioactive Waste Management Advisory Programme (WAMAP). Two regular WAMAP missions and one fact finding mission were conducted in 1992, compared with five in 1991. Activities in 1992 also reflected a transition period for the programme as the need for new missions is balanced against the requirement to establish a follow-up mechanism to assess progress achieved in implementing WAMAP recommendations.

Increased emphasis was placed on regional training courses, with three organized during the year (in the African, Latin American and Middle East/European regions). A specially developed curriculum covering planning, infrastructure components and the systems approach to radioactive waste management served as the basis for the courses.

A scientific afternoon at the regular session of the General Conference on the subject of radioactive waste management in countries with nuclear research and application activities provided the opportunity to present information on the need for a national waste management programme to decision makers and senior government officials.

The programme to prepare and distribute practical technical guidance in the areas of handling, processing and disposal of radioactive wastes for countries that generate small waste volumes was

on target at the end of the year after some initial difficulties were encountered in establishing the format and content of the documents. Five of the nine documents planned under the series (Technical Manuals for the Management of Low and Intermediate Level Wastes Generated at Small Nuclear Research Centres and by Radioisotope Users in Medicine, Research and Industry) were published in 1992. The new programme of assistance to Member States in the management of spent sealed sources was initiated during the year, with efforts commencing on documents on methods of locating spent radiation sources and a conceptual design of a standardized interim storage centre.

Actual conditioning of spent radiation sources was performed in some Member States to provide on-site demonstrations of the recommended technical procedures.

During the year, a number of newly introduced advisory missions and special tasks were undertaken as a result of urgent requests received from Member States for waste management expertise and guidance. Most of the assistance provided was in the form of fact finding missions to assess the safety aspects of uranium mine/mill tailing sites and the effectiveness of waste management infrastructures. A special mission was conducted to an African Member State to investigate the alleged dumping of radioactive waste from sources outside of the country. No evidence was found that such dumping had occurred. A programme to investigate and assess the consequences of the dumping of radioactive waste in Arctic seas was initiated with the Governments of Norway and the Russian Federation.

At the request of the Government of Ukraine, the Agency provided assistance to the Ministry of Ukraine for Chernobyl Affairs in soliciting international proposals for the safe and environmentally sound entombment of Unit 4 of the Chernobyl nuclear power plant complex.

There was increasing demand for IAEA-MEL's services across a widening range of high priority projects. In particular, the laboratory participated in a combined practical and theoretical assessment of the consequences of recently revealed past disposals of high activity reactor components in the marginal seas of the Arctic Ocean. Besides waste disposal impact assessment, IAEA-MEL's programme included analytical quality control services, in-house and field training, capacity building, radioactivity monitoring, radiological assessment, marine modelling, database provision, emergency response planning and the application of nuclear and isotopic techniques to the marine sciences, including assessment of post-war pollution in the Gulf, contributions to understanding the global carbon cycle and commencement of a Black Sea pollution tracer study.

The increase in unplanned activities experienced in the year, coupled with a shortfall in financial resources available to the programme, required a reassessment of programme priorities. This assessment resulted in the deferral or cancellation of lower priority tasks in the areas of minimization of waste generated from nuclear fuel cycle activities, in situ solidification for low and intermediate level radioactive waste and the evaluation of source upper bounds for marine disposal.

Management of spent radiation sources

Preparation continued of a publication in the IAEA-TECDOC Series that will provide Member States with advice on how to locate missing spent radiation sources and the establishment of a standardized design for a conditioning and interim storage facility for spent sealed sources. Also under development is a database registry that could be used to track spent radiation sources. This automated registry can assist Member States to record and store information on radiation sources from manufacturer to disposal. This special project is closely linked with WAMAP.

Handling, treatment, conditioning and storage of radioactive wastes

Minimizing radioactive wastes from nuclear fuel cycle facilities

Work continued on providing technical guidance to Member States on the minimization of radioactive wastes generated in the nuclear fuel cycle and from nuclear applications. Administrative, technical and procedural options which can be applicable at nuclear fuel cycle facilities to achieve the waste minimization goal are presented in a technical report that will be ready for publication in 1993.

State-of-the-art technology for substantial volume reduction of low and intermediate level radioactive waste is described in a technical report completed in 1992. The most efficient techniques include supercompaction, plasma arc incineration and melting and various decontamination methods.

Quality assurance and quality control for radioactive waste packages

Radioactive waste management, as any other industrial activity, requires planned and systematic actions to provide adequate confidence that the entire system, the process and the products involved will satisfy given requirements for quality. A first document in the Agency's programme on quality assurance of radioactive waste packages was completed in 1992 and published in the IAEA-TECDOC Series. It outlines the quality assurance requirements and methods which may be used in the determination of the characteristics specified in the acceptance criteria for high level liquid waste and spent fuel.

Advanced technologies for processing radioactive waste

To reflect the significant degree of research and development performed by Member States on the improvement of conditioning processes for radioactive waste, the Agency developed three Technical Reports Series publications. The first highlights progress in the area of cementation technology. This process is of special interest as there are increasing requirements for higher quality solidified waste forms. Various methods and techniques aimed at creating an improved waste form include: using special types of cements and admixtures; implementing advanced pretreatment techniques; and testing various mixtures and conditions to obtain a better understanding of the chemical interactions between matrix material and the waste. The second publication describes the progress achieved in bituminization processes for waste sludges and concentrates. The third focuses on one of the most important components of the waste package, the waste container. The report presents a review of and recommendations on the fabrication and handling of various containers used for shipping, storage and disposal of radioactive waste. All three publications will be issued in early 1993.

Advanced technologies for processing radioactive waste (cont.)

Research was sponsored by the Agency in the framework of a CRP on the use of inorganic sorbents to concentrate radionuclides in radioactive waste streams into solid materials suitable for further immobilization. This CRP was completed in 1991 and the final report was published in 1992 in the IAEA-TECDOC Series. A new CRP on waste treatment and immobilization technologies involving inorganic sorbents was established during the year in order to co-ordinate research in the field of the treatment and immobilization of low level liquid waste.

Direct assistance for waste management programmes in developing countries

As a result of increasing attention on the safety and reliability of some Soviet design WWER type reactors, emphasis has been placed on technical assistance to improve waste management practices at nuclear power plants with these reactors. Activities in this area come within the framework of a regional technical assistance project. The following main activities are involved:

- Re-establish communication channels after the breakup of the CMEA structure among eastern European countries with WWER type reactors;
- Identify and exchange information on common problems requiring immediate resolution;
- Identify and implement successful waste management practices;
- Publish in 1993 a status report on radioactive waste management for WWER type reactors.

Technical manuals for the handling and processing of radioactive waste

Progress was achieved in the preparation of technical manuals which are expected to meet the needs of Member States for safe, straightforward, reliable and low cost solutions to waste management problems. Five technical manuals were published in 1992 covering various steps in the management of low level radioactive wastes, starting from waste minimization and segregation to storage of conditioned waste.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1991	Performance of high level waste forms and packages under repository conditions	1995	13
1991	Treatment technologies for low and intermediate level wastes generated from nuclear applications	1995	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Waste treatment and immobilization technologies involving inorganic sorbents	4	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Radioactive waste management: A systems approach	Czechoslovakia	23	3 weeks
	Egypt	25	3 weeks
The management of spent radiation sources	Brazil	22	3 weeks

Publications

Series and No.	Title
Safety Series No. 108	Design and operation of radioactive waste incineration facilities: A safety guide
Technical Reports Series No. 337	Chemical precipitation processes for the treatment of aqueous radioactive waste
Technical Reports Series No. 339	Design and operation of high level waste vitrification and storage facilities
Technical Reports Series No. 345	Concepts for the conditioning of spent nuclear fuel for final waste disposal
IAEA-TECDOC-644	Guidance on radioactive waste management legislation for application to users of radioactive materials in medicine, research and industry
IAEA-TECDOC-652	Minimization and segregation of radioactive wastes
IAEA-TECDOC-653	Storage of radioactive wastes
IAEA-TECDOC-654	Handling and treatment of radioactive aqueous wastes
IAEA-TECDOC-655	Treatment and conditioning of radioactive solid wastes
IAEA-TECDOC-656	Treatment and conditioning of radioactive organic liquids
IAEA-TECDOC-675	Use of inorganic sorbents for treatment of liquid radioactive waste and backfill of underground repositories
IAEA-TECDOC-680	Quality assurance requirements and methods for high level waste package acceptability

Radioactive waste disposal

Technologies for near surface disposal systems for radioactive wastes

A report on the siting of near surface radioactive waste disposal facilities for Member States producing small annual quantities of radioactive waste has been prepared. It provides technical guidance on the procedures and guidelines for identifying and evaluating suitable near surface disposal sites. It is planned to be published in late 1993.

Preparation of a report on the design of near surface disposal facilities was initiated in 1992. It provides technical guidance on the processes required to plan and design a near surface disposal facility as well as an overview of available near surface disposal options.

Quality assurance requirements for waste disposal systems

A report was prepared on quality assurance for siting, design, construction, operation, closure and post-closure of radioactive waste disposal facilities. The document presents information on practical implementation of quality assurance programmes for the disposal of radioactive waste.

In preparation (for issue in 1993) is a report on the interfaces between the disposal system and the transportation system carrying high level radioactive waste packages to a geological disposal facility. The report is aimed at achieving a high level of understanding of the interfaces while recognizing the different technical and regulatory approaches in Member States. The report is scheduled to be published in late 1993.

Technologies for deep geological disposal systems for radioactive waste

A document is being prepared on Member State experience in the selection and characterization of sites for geological disposal of radioactive waste. The report describes the various siting strategies that have been employed by Member States, the stages of the site selection process, and the technical, social and economic factors that have been considered in site selection. Publication is planned for late 1993.

A symposium on the geological disposal of spent fuel, high level and alpha bearing wastes, organized jointly with the CEC and the OECD/NEA, was held in Antwerp, Belgium, in October. The technical presentations addressed disposal in all the principal geological media currently under consideration: clay, crystalline rock, salt and volcanic tuff. Presentations ranged from descriptions of very broad national screening activities by Member States early in their repository development programmes, to descriptions of very detailed investigations being performed in underground laboratories by Member States with relatively advanced programmes. The results of the Symposium showed that in spite of the variety of approaches, the technical problems are well identified, that the research and development programmes are concentrating on them, and that confidence in geological disposal is justified.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1991	Performance of engineered barrier materials in near surface disposal facilities	1995	13

Publications

Series and No.	Title
Special publication	Radioactive waste management: An IAEA source book
Technical Reports Series No. 342	Performance of engineered barriers in deep geological repositories
IAEA-TECDOC-637	Geochemistry of long lived transuranic actinides and fission products
IAEA-TECDOC-661	Review of available options for low level radioactive waste disposal

Decontamination and decommissioning of nuclear installations

Project planning and management for decommissioning operations

A guidebook on policy, regulation and planning for decommissioning large nuclear facilities is at an advanced stage of preparation. This document has been produced as a follow-up to Safety Series No. 105. It provides an overview of the various national decommissioning policies and regulatory frameworks with the objective of assisting future decision making. It presents the way in which commonly accepted principles are followed and compares the various approaches. Using specific examples it aims to provide factual information on the choices made and the reasons for them.

Decommissioning of research reactors

A planning and management guidebook for the decommissioning of research reactors and other small nuclear facilities was approved for publication. The document addresses the factors to be considered in the decision to decommission, describes a typical planning process for decommissioning, identifies the general requirements to satisfy the appropriate regulatory body, and provides a brief overview of activities necessary for completing successfully the overall decommissioning programme.

Cleanup of large areas after a nuclear accident

In the field of cleanup of large areas contaminated after a nuclear accident, a technical report assessing the rehabilitation, decommissioning and disposal alternatives for a nuclear reactor after a serious accident was completed and published during 1992. The objective of this report is to provide an overview of factors relevant to the identification of cleanup requirements and to the choice of a decommissioning option for a severely damaged nuclear power plant. A methodology is proposed to evaluate various options and to select an appropriate action in a particular accident situation.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Decontamination and decommissioning technology	1993	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional seminar for Asia and the Pacific on ageing, decommissioning and/or major refurbishment of research reactors	Thailand	38	1 week

Publications

Series and No.	Title
Technical Reports Series No. 330	Disposal of waste from the cleanup of large areas contaminated as a result of a nuclear accident
Technical Reports Series No. 333	Measurement and calculation of radon releases from uranium mill tailings
Technical Reports Series No. 334	Monitoring for compliance with criteria for unrestricted release related to decommissioning of nuclear facilities
Technical Reports Series No. 335	Current practices for the management and confinement of uranium mill tailings
Technical Reports Series No. 346	Cleanup and decommissioning of a nuclear reactor after a severe accident

Radiological and environmental aspects of waste management

Application of exemption principles to radioactive waste management

Since the international consensus on principles for exemption from regulatory control was issued in 1988 (Safety Series No. 89), work has been focused on applying the principles in the area of radioactive waste management. Several projects have been initiated, covering the areas of disposal and incineration of waste, and the recycle and reuse of contaminated materials from the nuclear fuel cycle. In 1991 a project was started which aimed to draw on all of the previous studies and to produce a set of unrestricted release levels in solid materials which could be applied irrespective of the possible fate of the material after release. Agreement on exempt values was reached at an Advisory Group meeting late in 1992. It is planned to publish the results of the work as a Safety Series report as part of the RADWASS programme.

Environmental studies in relation to marine disposal

The Agency has responded to concern over the possible health and environmental consequences of the dumping of high level radioactive waste in the shallow waters of the Kara and Barents Seas by establishing, in co-operation with the Governments of Norway and the Russian Federation, a programme of investigation and assessment. The programme aims to evaluate the present and potential future health and environmental impacts of the dumping and to consider the feasibility of possible remedial actions. The programme has the support of the Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972, formerly known as the London Dumping Convention). At the annual meeting in London in November 1992, the Agency's plans were fully endorsed. Contracting Parties were requested to assist to the extent possible and the Agency was requested to report its findings at the earliest opportunity.

Support for marine radioactivity monitoring

IAEA-MEL provides analytical quality control services (AQCS) to over 150 Member State institutions. During 1992, one worldwide radiological intercomparison exercise was completed and a further two samples were distributed. IAEA-MEL also arranged specific intercomparison exercises as part of its activities in the Co-ordinated Research and Environmental Surveillance Programme (CRESP) and in the Norwegian–Russian project on assessment of radioactive contamination in the Kara Sea. The laboratory also continued to play an important role in assisting the Helsinki Commission's Group of Experts on Monitoring of Radioactive Substances in the Baltic Sea. One intercomparison exercise on the measurement of ^{90}Sr and calcium isotopes in Baltic Sea sample IAEA-299 was completed.

Status of marine intercomparison exercises

Sample description	Status
IAEA-299, Baltic Sea water	Completed (report in preparation)
IAEA-134, Irish Sea cockle	1992 (ongoing)
IAEA-135, Irish Sea sediment	1992 (ongoing)
IAEA-315, Bombay sediment	Planned 1993
IAEA-300, Baltic sediment	Planned 1993
IAEA-378, Baltic sediment	Planned 1993
IAEA-379, Baltic sediment	Planned 1993

Support for marine radioactivity monitoring (cont.)

An active response was shown by Member State institutions participating in the Agency's regional Asian project on marine contaminant and sediment transport. The aim is to encourage adjoining nations to plan and implement co-operative research studies in the region and to promote the use and application of nuclear techniques to assess the source, trend and impact of contaminants on the marine environment.

IAEA-MEL, in co-operation with the Agency's Isotope Hydrology Laboratory, is co-ordinating a newly approved CRP on the application of tracer techniques in the study of processes and pollution in the Black Sea. On the basis of public concern related to the Chernobyl accident, a perceived high risk associated with some nuclear facilities in operation within the Black Sea basin and possible waste storage problems, riparian countries have identified radioactive pollution as a high priority problem requiring further research. These concerns are paralleled by the urgent need to develop the existing capabilities of riparian countries to make reliable isotopic and nuclear measurements.

During 1992, the Global Marine Radioactivity Database (GMRD) was initiated at IAEA-MEL. The database is designed to: (a) provide immediate and up to date information on the levels of radioactivity in the world's seas; (b) establish a baseline archive which may be used in impact assessment studies; (c) permit the investigation of temporal trends; and (d) identify gaps in available information. Information from the database will be available to all Member States on request. Around 30 000 items of data have already been entered, with initial emphasis on IAEA-MEL's own measurements during its 31 years of operation.

A start was made on the development of modern, sensitive and cost-effective methods of radioactivity monitoring and emergency response. In particular, the use of aerial gamma spectrometry using helicopter borne equipment was a feature of a survey, funded by the European Bank for Reconstruction and Development and implemented in co-operation with the Commissariat à l'énergie atomique and Equipe Cousteau, of more than 2000 km of the Danube river banks from Budapest to the Black Sea, plus aerial mapping of the environments of nine selected near-river industrial sites, both nuclear and non-nuclear. Combined aerial and ground measurements showed that the Danube River and catchment are radiologically 'clean' both in absolute terms and in comparison to other European rivers. The only man-made radioactivity consistently observed is from fallout from the Chernobyl accident and the levels are relatively low, decreasing systematically from Budapest to the Black Sea. A remeasurement of Chernobyl fallout in the vicinity of the Kozloduy nuclear site suggests a general level of deposition of less than one-tenth that previously reported. Major variations in radiation environment are noticeable as a result of differing activities of natural radionuclides.

Radionuclides in the marine environment

IAEA-MEL took part during August/September in a joint Norwegian–Russian expedition to the Kara and Barents Seas. The participation of the Agency provided both technical support and independent international representation. A series of marine sediment samples is currently being analysed for radioactivity content. IAEA-MEL has also organized a specific analytical quality assurance exercise by distributing Kara Sea sediment samples to Norwegian and Russian laboratories. Preliminary results provide independent confirmation of the shipboard finding that radioactive contamination in the Kara Sea in general is currently extremely low and presents no significant radiological danger. To support this radioanalytical programme, IAEA-MEL has developed a set of

computer models to be used for the assessment of the regional and global dispersal of contaminants.

As part of its activities in the Co-ordinated Research and Environmental Surveillance Programme (CRESP) in co-operation with OECD/NEA, IAEA-MEL participated in an oceanographic cruise to the North East Atlantic Dump Site in March 1992. A main objective of the cruise, organized by the Bundesforschungsanstalt für Fischerei, Hamburg, was to perform an intercomparison analysis for ^{137}Cs, $^{239,240}Pu$ and ^{241}Am in water samples collected above the sea-bed at the waste disposal site. Samples were also collected for ^{14}C measurements in collaboration with the University of Arizona's Accelerator Mass Spectrometry Facility. The results suggest that radiologically negligible but measurable leakage of plutonium isotopes is occurring at the site.

Efforts were made towards improving methods of analyses of radioactivity in marine samples.

IAEA-MEL continued its participation in oceanographic cruises in the northwestern Mediterranean Sea and elsewhere to measure the vertical flux and inventories of radionuclides and globally important elements such as carbon. Results have shown that the downward sinking of particulate carbon is primarily driven by the biological productivity in the overlying surface waters. Such carbon fluxes are not constant but fluctuate greatly, sometimes by orders of magnitude, depending upon the type and number of marine organisms in the upper water layers. The fluctuations in particle sinking also affect the removal of long lived radionuclides from surface waters and their subsequent transport to depth. Such studies are crucial to the understanding and prediction of radionuclide fates in the oceans.

In related work, multi-isotope techniques have been developed to follow uptake, transfer and excretion in a single individual organism. With similar techniques using two radioisotopes of cobalt, the passage and fractionation of inorganic and organic cobalt has been traced through a simple marine foodchain including phytoplankton, zooplankton and fish.

Radionuclides in the marine environment (cont.)

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Validation of models for the transfer of radionuclides in terrestrial, urban and marine environments (VAMP)	1994	62
1988	Sources of radioactivity in the marine environment and their relative contributions to overall dose assessment from marine radioactivity	1993	17
1990	Safety assessment of near surface radioactive waste disposal facilities (NSARS)	1995	17

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of tracer techniques in the study of processes and pollution in the Black Sea	3	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
Strategies and methodologies for applied marine radioactivity studies	Mexico	25	2 weeks

Publications

Series and No.	Title
Technical Reports Series No. 332	Effects of ionizing radiation on plants and animals at levels implied by current radiation protection standards
IAEA-TECDOC-647	Modelling of resuspension, seasonality and losses during food processing: First report of the VAMP Terrestrial Working Group
GESAMP Reports and Studies No. 40	Report of the twenty second session

Waste management planning and infrastructure

Information on waste management

The first biennial issue of the Waste Management Research Abstracts (Issue No. 21) was published in late 1992. As in previous issues, it contains over 700 research abstracts from 35 countries and international organizations. In anticipation of the next issue, to be published in 1994, a special Research-in-Progress database project has been implemented to automate and improve data processing and retrieval. The first phase of the project is expected to streamline production, increase the search and indexing capabilities and improve the overall quality of the document. On-line access of the information may be possible in the near future.

Radioactive Waste Safety Standards (RADWASS)

Considerable progress toward the development of safety related consensus documents within the Radioactive Waste Safety Standards (RADWASS) programme was achieved. The programme contains 24 publications at the hierarchical levels of Safety Fundamentals (1), Safety Standards (6) and Safety Guides (17). Safety Practices will be defined as necessary. The programme will be carried out in two phases. Phase I (1991-1994) includes nine documents of the highest priority. Two Safety Practices on waste exemption were added to the programme in 1992.

A very elaborate preparation process is being applied. This requires extensive reviews and revisions to achieve international consensus before the manuscripts are submitted for publication. Progress is reflected by the following activities:

- Five Standing Technical Committee meetings and eight consultants meetings were held;
- Five documents were submitted for review to the International Radioactive Waste Management Advisory Committee (INWAC).

The advanced stage of the ongoing RADWASS programme is illustrated by the following accomplishments:

- One Safety Practices document was published in 1992 and the second will follow in 1993;
- Three Safety Guides will be ready for publication in 1993;
- Five Safety Fundamentals and Safety Standards documents are in an advanced state of completion and can be submitted for review by Member States in 1993.

It is expected that the goal to have all RADWASS Phase I documents published or ready for publication in 1994 can be achieved.

Publications

Series and No.	Title
Safety Series No. 111-P-1.1	Application of exemption principles to the recycle and reuse of materials from nuclear facilities
Special publication	Radioactive waste safety series (RADWASS) programme
WMRA/21	Waste management research abstracts

COMPARATIVE ASSESSMENT OF NUCLEAR POWER AND OTHER ENERGY SOURCES

Programme overview

All fuel chains within the electricity generation system involve some health risks and lead to some environmental impacts. This factor, together with the emerging needs of many countries to define their electricity demand and supply options for the coming decades, has stimulated a growing interest in the application of improved data, tools and techniques for the comparative assessment of different electricity generating systems, particularly from the environmental and human health viewpoints, as well as on the basis of technical and economic performance indicators.

In response to this interest, the Agency introduced a subprogramme in 1991–1992 on the comparative assessment of nuclear power and other energy sources in order to achieve stronger integration and co-ordination of various tasks within the Agency related to this area. At the same time, new initiatives were taken to strengthen co-operation with other organizations involved in related work. The 1991 Senior Expert Symposium on Electricity and the Environment, jointly organized by the Agency and ten other organizations and held in Helsinki, Finland, was an important outcome of this interagency co-operation.

Against this background, the Agency convened a meeting in May 1992 of international organizations to discuss the establishment of a joint project on databases and methodologies for the comparative assessment of different energy sources for electricity generation, a topic that the Senior Expert Symposium had identified as being of high priority for follow-up work. This project would seek to provide information, data and a catalogue of methodologies that would be useful for international organizations and for planning organizations in their Member States, especially developing countries, in improving their abilities to make comparative assessments of different energy chains and technologies for electricity generation. The co-ordination meeting endorsed, in principle, a proposal to establish a joint project to: (1) review, harmonize and fill gaps in databases on the technical, economic, health and environmental parameters of energy chains for electricity generation; (2) make the resulting data available through a user oriented data management system for use in planning studies in the electricity sector; and (3) review, catalogue and improve methodologies for comparative assessment. Following the meeting, a draft project outline was prepared by the Agency and circulated to the different organizations for their consideration. Another meeting of the interested organizations is planned for early 1993. The secretariat for the project will be the 'Vienna Four', i.e. the four international organizations based in Vienna: the Agency, IIASA, OPEC and UNIDO.

With the objective of establishing an international authoritative database on the health and environmental impact of energy systems, the methodologies and data needs for comparative assessments were analysed. A user friendly interactive computerized database structure was developed and tested; this database would be used to store information available in Member States and international organizations.

In co-operation with UNEP, UNIDO and WHO, a risk management procedures guide was developed and complemented with a collection of related computer codes. In addition to being widely distributed, this guide is being used to support case studies in eight Member States and is being used in several other Member States to define the scope of risk management studies.

Owing to reductions in the budget, ongoing work on comparative assessment and activities related to the transmitting of information to other organizations was postponed.

Assessment of generation costs of nuclear and other energy systems

A review of methodologies continued with the assistance of consultants to assess the economics of renewable energy systems, particularly solar and wind power, for electricity generation, taking into account their stochastic availability versus the baseload character of nuclear and fossil fuel fired power plants.

Work continued in co-operation with the OECD/NEA and IEA on electricity generation costs of nuclear and other power plants, with a report due to be published in 1993. The Agency contributed to this joint activity mainly by providing information and data regarding generation cost comparisons in non-OECD countries.

Work continued in co-operation with the OECD/NEA on nuclear fuel cycle costs. A report will be published in 1993.

On the basis of currently available cost data, an assessment and comparative study of waste management system costs for nuclear and fossil fuel electricity generation was completed. The study was carried out using several representative reference fuel cycles: a PWR with and without spent fuel reprocessing to represent the nuclear case and a conventional coal fuelled plant and a gas fuelled combined cycle to represent the fossil fuel case. It was found that for both cases (nuclear and fossil fuel), the reference waste management costs represented a small to moderate fraction of the overall cost of electricity generation. The highest waste management costs were those associated with a conventional coal plant with controls to manage the emissions of particulates, SO_2 and NO_x. The lowest costs were those associated with the gas fuelled combined cycle. A report is scheduled for publication in 1993.

Comparative assessment of the health and environmental impact of nuclear power and other energy systems

A Technical Committee meeting on the health and environmental impact (including non-radioactive factors) of nuclear fuel cycle facilities under normal and accident conditions was held in Vienna. Four types of nuclear fuel cycle were defined from the viewpoint of commercially proven technologies. A preliminary list of the technical characteristics of emissions was developed and significant radionuclides and common examples of chemical pollutants were highlighted. It was stressed that data should be collected on parameters of other energy sources, as well as on the nuclear fuel cycle, in order to assess fairly the health and environmental impact.

IAEA/UNEP/UNIDO/WHO project on risk assessment

Work continued on the interagency IAEA/UNEP/UNIDO/WHO project on the assessment and management of the health and environmental risks of energy and other complex industrial systems:

- A procedural guide on risk management, discussed and approved in principle at an international workshop held in Tel Aviv, Israel, in November 1991, was finalized and will be published in 1993 by the Agency on behalf of the four participating organizations. A risk prioritization manual has also been developed and will be published in 1993.
- As part of the project, case studies have been carried out in 15 countries. Reports were published on the studies in North Bohemia, Czechoslovakia, and in Copsa Mica, Romania.
- Computer codes were developed for risk assessment and the management of air and surface waste pollution in large industrial complexes. A computerized simulation and decision support tool, Health, Environment and Risk Assessment and Management of Industrial/Energy Systems (HERAMIS), has been developed by the Agency as a comprehensive software package incorporating all the information available from this

IAEA/UNEP/UNIDO/ WHO project on risk assessment (cont.)

interagency project, including the procedural guide and the available case study reports. Included in HERAMIS are numerical databases, information in hypertext form and decision simulation modelling systems.

A manual on risk prioritization was finalized and a prototype expert system, PRIORITIZE, is now available for testing.

Comparative assessment of the ecological impact and effect on climate change of nuclear and other energy systems

The work of the IPCC continued to be supported by the Agency through participation in meetings of the IPCC Plenary and its topical Working Groups. The contributions of the Agency were aimed at ensuring that there was an objective consideration of the potential role of nuclear power in strategies seeking to reduce greenhouse gas emissions.

A Technical Committee meeting was organized to examine methods and models for estimating the global circulation of selected environmental emissions from energy generation (carbon dioxide, tritium, ^{85}Kr, ^{14}C, ^{129}I, etc.). The main purpose of the meeting was to exchange information on the relevant methods and models that have been developed to assist in the understanding of the various mechanisms by which these emissions, once generated, are dispersed and circulated through the global environment.

A pilot version of a computerized database called HEIES (Health Environmental Impact Energy Systems) was developed and discussed at another Technical Committee meeting. Additional work is continuing on a test version of this database.

Incorporation of comparative assessments in energy and electricity planning

Work continued on specific aspects of the comparative assessment of nuclear power and other energy sources, in particular with regard to the outcome of UNCED and the programme of Agenda 21:

- A paper on the role of nuclear energy in safe and environmentally benign power generation in central and eastern European countries was presented at the Second International Symposium of the World Energy System, held in Budapest, Hungary, in October.
- The Agency contributed to major international meetings on the analysis and comparative assessment of the health and environmental impact of electricity systems, presenting information on the economics and environmental aspects of nuclear power.
- Work continued on the design and implementation of a harmonized reference database on technical, economic, health and environmental indicators of energy systems for electricity generation.
- A preliminary review of methodologies and models for the comparative assessment of energy sources for electricity generation was undertaken and a working document was published. The review will be completed in 1993 and published in a catalogue, which will be one of the outcomes of the joint interagency project.
- Economic, health and environmental indicators of electricity systems based on renewable energies were reviewed and a report was published.
- The Agency participated in the preparation of an energy dictionary, published by the WEC in September 1992, by contributing to the sections on nuclear fission and fusion energy terminology.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interagency course on comprehensive risk assessment and management	Netherlands	15	2 weeks

Publications

Series and No.	Title
Special publication	Nuclear power, nuclear techniques and sustainable development
IAEA-TECDOC-645	Format and structure of a database on health and environmental impacts of different energy systems for electricity generation
IAEA-TECDOC-646	Renewable energy sources for electricity generation in selected developed countries
IAEA-TECDOC-671	Methods for comparative risk assessment of different energy sources

FOOD AND AGRICULTURE

Programme overview

The food and agriculture programme operated jointly with FAO is designed to assist Member States in using nuclear techniques in their agricultural research and development to improve food production, reduce food losses and protect the environment. In keeping with worldwide trends, greater emphasis is being placed on nuclear biotechnology tools and on environmental problems.

In seeking to contribute to increasing and sustaining soil fertility and crop production in Member States, the Agency's activities in 1992 were focused on identifying and selecting genotypes of crops that are capable of growing and producing well in soils low in plant nutrients, especially phosphorus, and in saline and acidic soils, and under drought conditions. Of particular importance is the discovery of a wheat genotype in Morocco with both high yield and high water use efficiency.

Increased emphasis was placed on workshops, one of which was held in Africa and the other in the Middle East/Europe region. The workshop in Africa trained technicians in the operation and maintenance of emission spectrometers for ^{15}N analysis, and strengthened the regional Africa technical co-operation project on biological nitrogen fixation.

A scientific afternoon at the regular session of the General Conference on the subject of nuclear applications for improving everyday life provided the opportunity to highlight to policy makers and officials of Member States the use and applications of isotope studies on biological nitrogen fixation for productive and sustainable agriculture.

The increase in activities planned, especially in the areas of irrigation scheduling and crop water management coincided with a reduction in the budget, necessitating a reassessment of priorities and activities. This may result in deferral, or cancellation, of some tasks in the coming year.

Increased emphasis was placed on a project on the genetic improvement of basic food crops in Africa. In accordance with the recommendations of a steering committee, efforts will also concentrate on the domestication of local plant species as sources of food. The project has already demonstrated that mutation techniques, in combination with the use of advanced biotechnologies, are the most suitable for accelerating the domestication process.

A project evaluation mission examining the first phase of the regional project on cereal improvement in Latin America found that through an intensive training programme, expert services and a research network organized as a CRP, it was possible to integrate on a large scale modern mutation techniques into plant breeding practices. Recently established biotechnology/mutation technique laboratories in most of the participating countries have already undertaken the production of new, mutated plant material.

National animal production and veterinary institutes were supported in the use of radioimmunoassay, enzyme immunoassay and DNA probes within the framework of programmes to improve the sustainability of livestock production systems through better feeding and reproductive management and diagnosis and control of animal diseases. Very significant strides were made towards the eradication of rinderpest from Africa, so that the disease now occurs in only two countries. Considerable progress was made in developing an international reference centre for animal disease diagnostics.

The power of the sterile insect technique (SIT) as an ecologically selective method for managing major insect pest problems was demonstrated by the successful eradication of the New World Screwworm from the Libyan Arab Jamahiriya. A major advance was made in improving the economy and effectiveness of SIT by the successful development of a strain of the Mediterranean fruit fly. Major economies will also be realized in the mass rearing of the strain.

A programme to eradicate the tsetse fly from Zanzibar Island, United Republic of Tanzania, is progressing. It promises to yield proven technologies for eradicating the vectors of African animal trypanosomiasis from many parts of Africa.

The two main themes of the agrochemicals and residues subprogramme are the application of nuclear and related methods to monitor the behaviour, effects and fate of pesticides in food and the environment, and the development of formulations for specific situations to improve the performance and environmental compatibility of pesticides. A third theme is the development of guidelines for alleviating the effects of radionuclide contamination in agricultural systems. Discussions are under way with FAO concerning the advisability of establishing a training and analytical quality assurance laboratory to assist developing Member States in the regulation and safe and environmentally benign use of pesticides. However, a reduction in the budget prevented the completion of a document on agricultural countermeasures to be taken in the event of a nuclear accident.

General Conference Resolution GC(XXXVI)/RES/588 directs the Agency to prepare, in consultation with other United Nations organizations, a project proposal for the practical utilization of food irradiation in developing countries. An action plan has been developed for consideration by the Board of Governors.

Three additional food irradiators, in France, Indonesia and the USA, became available in 1992 for processing food and other products. These bring the total number of irradiation facilities available for food processing to 53. Demonstration irradiation facilities are being installed in Bangladesh and Ghana.

Owing to reductions made in the budget, a CRP on the epidemiology of control of foodborne diseases had to be postponed to 1993.

Soil fertility, irrigation and crop production

Maximizing biological nitrogen fixation and yield of pasture and grain legumes

A CRP on improvement of the yield and N_2 fixation of grain legumes in Southeast Asia seeks to identify grain legume cultivars with a high capacity for both fixation and yield. The two approaches adopted are: (a) screening existing germplasm for high biological nitrogen fixation and yield, and (b) breeding or using induced mutations to produce legumes with both high nitrogen fixing ability and yield. Many genotypes are high in N_2 fixation but not in yield, or vice versa. Fortunately, N_2 fixation is heritable and therefore it should be possible to enhance N_2 fixation in high yielding lines.

Measurement and management of nitrogen fixation by tree species

In a CRP on optimization of N_2 fixation by tree crops for enhancing soil fertility and soil conservation, ^{15}N methodology is being applied to select trees for use in agroforestry or to provide fuel wood. Data on genotypic differences in nodulation, growth and N_2 fixation were reported. In many cases, nodulation problems were encountered that greatly affected N_2 fixation. The ^{15}N natural abundance method for measuring N_2 fixation was also tested. However, the decline in $\delta^{15}N$ under the reference trees could make the estimates of N_2 fixation unreliable.

Optimizing the use of fertilizers for plant productivity

A CRP on increasing and stabilizing plant productivity in low phosphate soils in the tropics and subtropics has involved the search for genotypes of food crops and trees which are highly efficient in the use of limited supplies of water and phosphorus. Both high grain yield and high water use efficiency were discovered in the same genotype. This is a rare find which will have substantial implications in increasing and sustaining wheat production in drought prone regions. On the basis of this encouraging development, screening has now been expanded to a wider germplasm base in order to ensure that elite genotypes are not missed. Detailed studies of wheat cultivars high in phosphate use efficiency showed that they have higher root densities and a higher number of grains per head. Thus, through breeding, varieties of crops that not only grow well in phosphorus deficient soils, but also produce good yields can be developed.

Increasing the efficiency of water application and use

A CRP was initiated on the assessment of irrigation schedules of field crops to increase the effective use of water in irrigation projects. Recently published research suggests that exposing plants to water stress at specific growth stages may not cause significant decreases in yield. Therefore, irrigation during these stages can be omitted.

Increasing plant productivity in saline soils and prevention of salinization

A CRP on the use of nuclear techniques to improve crop production in salt affected soils has shown that a wide range of genetic variability exists in crop and tree species for salt tolerance. The crops studied included lentil, rice, soybean, wheat, barley, sorghum and millet. Among the trees tested were *Casuarina*, *Eucalyptus*, *Parkinsonia*, *Teminalia* and *Sesbania* species. In India and Pakistan, cultivation of salt tolerant varieties of rice, wheat, barley and *Sesbania* resulted in the amelioration of salt affected soils, while in Nigeria, sorghum and millet grown in saline soils significantly decreased both soil salinity and sodicity. The programme also examined plant physiological mechanisms controlling salt tolerance using ^{22}Na and ^{36}Cl as tracers. The data indicate that salt tolerance in barley is partly due to selective uptake of K over Na. In soybean, salt tolerant cultivars accumulated more K than Na in their tissues.

Laboratory activities

The Soil Science Unit of the Agency's Laboratory at Seibersdorf continued to provide technical support to CRPs and technical co-operation projects.

Work on biological nitrogen fixation of grain legumes and microbial ecology resulted in development of a new methodology to identify root nodulating bacteria using a marker gene (*gusA*). This gene was transferred in the laboratory from *E. coli* to *Rhizobium*, where it can easily be identified by blue colour production.

The Unit provided 30 person-months of training to 7 fellows on the use of nuclear techniques in soil/plant relationships and isotope analysis. Analytical services, mainly nitrogen isotope determinations for approximately 10 000 samples, were provided for research contract and technical co-operation programmes. A pilot external quality assurance programme for ^{15}N measurement was carried out in Latin America.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Use of nuclear and isotopic techniques to improve crop production in salt affected soils	1993	10
1989	Increasing and stabilizing plant productivity in low P and semi-arid and subhumid soils of the tropics and subtropics	1994	14
1990	Management of N_2 fixation by trees for enhancing soil fertility and soil conservation in fragile tropical soils	1994	14
1990	Improvement of yield and N_2 fixation of grain legumes in tropics and subtropics of Asia	1994	13
1990	Use of nuclear and related techniques in the assessment of irrigation schedules of field crops to increase the effective use of water in irrigation projects	1995	17

CRPs established in the current year

Subject	No. of years	Participating institutions
Use of molecular biology studies of microbial ecology	4	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the use of isotope and radiation techniques to enhance biological nitrogen fixation	IAEA Seibersdorf	21	5 weeks
Regional course on the use of isotope and radiation techniques in studies on soil/plant productivity	Chile	15	5 weeks

Publications

Series and No.	Title
IAEA-TECDOC-674	Manual on measurement of methane and nitrous oxide emissions from agriculture
Newsletter	Soils newsletter, Vol. 15, Nos 1 and 2

Plant breeding and genetics

Cereal improvement in Latin America

The first phase of the regional project on cereal improvement in Latin America (ARCAL VII) has been largely completed. A project evaluation mission found that through an intensive training programme, expert services and a research network organized as a CRP (in this case on the improvement of rice and other cereals through mutation breeding in Latin America), it was possible to integrate on a large scale modern mutation techniques into plant breeding practices. Recently established biotechnology/mutation technique laboratories in most of the participating countries have already undertaken the production of new, mutated plant material. These laboratories are also being used to train students and young plant breeders in these effective technologies.

Genetic improvement of basic food crops in Africa

Increased emphasis was placed on the genetic improvement of basic food crops in Africa. In accordance with the recommendations of a steering committee, this project will also concentrate on the domestication of local plant species as sources of food. The project has demonstrated that mutation techniques, in combination with the use of advanced biotechnologies, are the most suitable for accelerating the domestication process.

Genetic improvement of oil seed and industrial crops

The potential of the seed irradiation technique for crop improvement was confirmed by results from a CRP on the mutation breeding of oil seed crops. Participants from Bangladesh, China, Egypt, Germany, Greece, Israel, Pakistan, Philippines, Poland, Romania, Sri Lanka and Thailand have developed a great number of very valuable mutants in sesame, rape, sunflower, castor and poppy seeds. These new mutants determine such agronomically desired characters as higher yield, pest and disease resistance and modified fatty acid composition. Especially promising mutants that affect the fatty acids of sesame were obtained in Egypt.

Biotechnology for improvement of cereals and other grain crops

A CRP on the use of induced mutations in connection with haploids and heterogenesis in cereals, which ended in 1992, resulted in a new mutant of great importance for hybrid rice (in China), as well as other valuable mutants and doubled haploid lines. By applying radiation (^{60}Co) to in vitro culture, cytoplasmic male sterility was induced in rice. This new mutant also shows other very desirable characteristics which make rice hybrid seed production more economical. A new method of hybrid seed production was developed in Hungary using induced nutritional tomato mutants. Progress was achieved in doubled haploid production methodology for cereals (in Canada, Hungary, Japan, Poland, the United Kingdom, USA and at the International Rice Research Institute). Moreover, the newly developed isolated microspore culture system in cereals (Canada) is not only very suitable for use in mutation induction and selection, but also for the application of molecular genetics to cereal breeding. A new rice mutant variety was officially released as a result of this CRP (mutant variety Hezu 8, in China).

Laboratory activities

Research and development work by the Plant Breeding Unit of the Agency's Laboratory at Seibersdorf on in vitro mutation breeding systems for vegetatively propagated tropical crops was concentrated on the following activities:

- In vitro mutation induction and breeding of *Musa* (banana and plantain) for improved agronomic qualities and disease resistance. The mutant clone GN-60A was induced by gamma irradiation from the dessert banana cultivar

Laboratory activities (cont.)

'Grand Nain'. The clonal progeny expressed earlier flowering habit, a higher quality of fruits and better yield than the original cultivar. Mutant clones were induced in other cultivars of banana and plantain for field testing in Member States. Molecular biological and isotope techniques were used for genetic characterization (DNA 'fingerprinting') of mutants and cultivars of banana and plantain. Techniques were developed for inducing polyploidy and for measurement of the DNA content of different *Musa* genotypes.

- Comparative mutagenesis (radiation and chemicals) was tested in cassava for inducing genetic variation for breeding. Chromosome mutants (polyploids) were produced for field testing in tropical countries.
- Vegetatively propagated clones of sugarcane originating from tissue culture after mutagenic irradiation are being selected for tolerance to abiotic stresses (salinity and drought) under field conditions.
- Mutation breeding of *Azolla-Anabaena* nitrogen fixing organisms focused on the improvement of tolerance to salinity, acidity and aluminium tolerance in rice paddy. Promising strains were despatched to Member States for field testing.

In-service training was provided to seven fellows (49 person-months) in the application of advanced mutation techniques and related biotechnologies and molecular biology methods in plant breeding. The results of the Unit's work were published in 11 scientific papers and staff made presentations at four international meetings. A mutation induction service using gamma irradiation and fast neutrons in seeds, plant propagules and tissue cultures of 56 plant species from 400 cultivars was provided to plant breeding institutes in 43 developing Member States.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Improvement of rice and other cereals through mutation breeding in Latin America	1992	13
1988	Mutation breeding of oil seed crops	1993	17
1988	Improvement of root and tuber crops in tropical countries of Asia by induced mutations	1993	8
1988	In vitro mutation breeding of bananas and plantains	1992	8
1989	Improvement of basic food crops in Africa through plant breeding including the use of induced mutations	1994	16

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of DNA based marker mutations for improvement of cereals and other sexually reproduced crop species	5	13
Use of novel DNA fingerprinting techniques for the detection and characterization of genetic variation in vegetatively propagated crop plants	5	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the induction and use of mutations in plant breeding	IAEA Seibersdorf	20	6 weeks
Interregional group training on the genetic basis of mutation and related techniques for crop improvement	Poland	8	12 months
Regional course on advanced mutation breeding of tropical crop plants	India	11	2 weeks

Publications

Series and No.	Title
Newsletter	Mutation breeding newsletter Nos 38, 39
Newsletter	Mutation breeding review No. 8

Animal production and health

Development of diets and feeding strategies for ruminant livestock

Through regional and interregional CRPs, studies were conducted on the value of locally available grasses, crop residues and agro-industrial by-products for improving the growth rates and/or reproductive efficiency of indigenous ruminants, and thereby the amount of meat and milk produced. Two CRPs were concluded. The first dealt with the development of feeding strategies for improving cattle, sheep and goat productivity in areas of fluctuating nutrient supply. Attention was given to the use of cereal straws and stovers as feedstuffs, and various methods were employed to improve their utilization, e.g. treatment, provision of supplements (urea, *Glyricidia*, cassava leaves and palm kernel cake). These approaches led to considerable increases in the growth rates of cattle and sheep, and in a number of instances to improved reproductive efficiency. One of the major recommendations was the need in future programmes to identify the objectives of supplementation since individuals within animal populations have different requirements.

Application of RIA methods for livestock reproductive management

Measurements of the reproductive hormone progesterone by radioimmunoassay (RIA) coupled with the analysis of breeding records were used in three regional CRPs to identify the factors which adversely influence the ovarian actvity of animals kept by resource-poor farmers in Africa, Asia and Latin America, and to find ways of overcoming these factors. One of the most striking features of the data collected was the large within-breed variations recorded on individual farms or in institutional herds with respect to the parameters measured; these parameters also varied enormously in animals of the same genotype kept on different farms. Variations in the reproductive performance of indigenous sheep and goats were of a similar order. Such dramatic differences in reproductive efficiency not only demonstrated the great scope for improving overall productivity, but confirmed that developing Member States have animal genetic resources which can be productive even under conditions of suboptimal management. This project also confirmed that the major thrust for improving productivity lies in these indigenous breeds and not in imported exotic livestock.

The importance of nutrition was mainly demonstrated by the strong correlations recorded at a number of locations between the season and such factors as the onset of puberty, the duration of postpartum acyclicity, conception rates, generation intervals and the number of surviving offspring. This suggests that, particularly in situations where there is a limited possibility of making nutritional interventions, more disciplined management of livestock breeding would significantly improve individual animal and herd performance.

Seromonitoring of rinderpest in support of the Pan-African Rinderpest Campaign (PARC)

Support continued to be provided to 26 institutes in 15 Member States in the use of a standardized immunoassay developed by FAO/IAEA and the Pirbright Laboratories, the United Kingdom, to test the blood of cattle for the presence of antibodies against rinderpest after animals have been vaccinated against the disease. Monitoring of animals in this way enables an assessment to be made of the efficacy of national vaccination campaigns for controlling and eventually eradicating the disease. Analysis of the results from over half a million sera in the participating countries in the past year has shown that the prevalence of antibodies in almost all national herds is now higher than at any time in the past,

Seromonitoring of rinderpest in support of the Pan-African Rinderpest Campaign (PARC) (cont.)

suggesting that the regionwide vaccination campaign is succeeding in its aim of protecting animals against infection. However, in three Member States the number of animals with antibodies to rinderpest remains too low to prevent the spread of disease; if continued, this situation will delay the attainment of regional eradication.

Validation and use of immunoassay tests for the diagnosis of trypanosomiasis in African livestock

This activity involved the transfer to 11 African Member States of standardized immunoasay tests for the diagnosis of trypanosomiasis in cattle and camels. A significant achievement was that the assays and training provided to local staff increased considerably knowledge of the epidemiology of animal trypanosomiasis in the participating countries. The immunoassay systems, which detect minute quantities of species-specific invariant trypanosomal antigens, were shown to be especially useful in situations where the presence of trypanosomes could not be detected by conventional parasitological techniques, e.g. in cases of chronic trypanosomiasis.

Development and validation of immunoassay test kits for the diagnosis of selected viral, bacterial and parasitic diseases

In line with its commitment to the international standardization of diagnostic techniques for animal diseases, the Agency is now represented on the Standards Commission of the International Office of Epizootics. Through this commission, the Agency is assisting in drawing up international guidelines for the expression of results based on immunoassay diagnostic methods, contributing to standardization by the distribution of diagnostic kits and reference standards, and by organizing the quality control of assays. In addition, through CRPs and technical co-operation activities, the Agency is participating in the international standardization and validation of immunoassay techniques for rinderpest, foot and mouth disease, brucellosis, trypanosomiasis and other viral, bacterial and parasitic diseases of livestock.

Laboratory activities

The Animal Production Unit of the Agency's Laboratory at Seibersdorf continued to provide technical support, primarily through the production and distribution of standardized and validated kits for hormone measurement and disease diagnostics. Radioimmunoassay kits for the measurement of progesterone in milk and blood were distributed to approximately seventy counterpart laboratories. Kits for the measurement of eight metabolic parameters were developed and validated and are now being used to assess and monitor the nutritional status of indigenous livestock species. Enzyme linked immunosorbent assay kits equivalent to 0.7 million assay units were provided for the diagnosis of infectious diseases to over seventy-five Member States in Africa, Asia and Latin America.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Strengthening animal production research and disease diagnosis in Asia through the application of immunoassay techniques	1993	23
1990	Development of feed supplementation strategies for improving ruminant productivity on smallholder farms in Latin America through the use of immunoassay techniques	1994	21
1987	Rinderpest serosurveillance in Africa under PARC	1996	23
1990	Immunoassay methods for the diagnosis and epidemiology of animal diseases in Latin America	1995	26
1990	Interregional network for improving the productivity of camelids	1995	20

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of supplementation strategies for milk producing animals in tropical and subtropical environments through the use of nuclear and related techniques	5	20

Publications

Series and No.	Title
IAEA-TECDOC-657	Regional network for Latin America on animal disease diagnosis using immunoassay and labelled DNA probe techniques
IAEA-TECDOC-674	Manual on measurement of methane and nitrous oxide emissions from agriculture
Newsletter	Animal production and health newsletter, Nos 13 and 14

Insect and pest control

Increased efficacy and reduced cost of medfly eradication using SIT

A Research Co-ordination meeting for a CRP on laboratory and field evaluation of genetically altered medflies for use in sterile insect technique (SIT) programmes was held in Pavia, Italy, to assess the present status and evaluate the performance of genetically altered medfly strains. The participants agreed that emphasis should now be placed on using these strains in field programmes.

In studies carried out at the Agency's Laboratory at Seibersdorf, and partially supported by the United States Department of Agriculture, it was shown that many different isolates of *Bacillus thuringiensis* produce a variety of biocidal agents that are active against adult medflies. The activity of some heat stable soluble products could be altered by modifying the fermentation medium. No isolates were found that produced high levels of activity that could be ascribed to the δ-endotoxin.

Development of advanced fruit fly rearing systems

Several genetic sexing strains were successfully reared in the medfly mass rearing facility. Preliminary small scale field tests with males produced through this technique gave promising results.

Transfer of medfly eradication technology

In North Africa, a project known as Maghrebmed has been evaluating the feasibility of medfly eradication from four countries: Algeria, the Libyan Arab Jamahiriya, Morocco and Tunisia. In these countries, the medfly causes direct losses of $90 million per year. Initial activities have included delineating the medfly infested areas, obtaining climatic and phenological data, developing and utilizing a computer program to manage the data, conducting studies on the potential economic returns of alternative strategies for meeting this problem, designing one or more pilot eradication projects (primarily to train local staff) and extensive training of national staff. The next phase will involve one or more pilot eradication projects and other activities necessary for implementation of the eradication programme. Other species of fruit fly are the targets of activities in Pakistan, the Philippines and Thailand.

Improved tsetse rearing technology

Six tsetse fly species of economic importance were maintained at the Agency's Laboratory at Seibersdorf. Two of the tsetse colonies were mass reared to provide excess insect material to tsetse control projects in Africa. Others were held at a level sufficient to maintain the strain and provide enough fly material for in-house research and for collaborating institutes in Agency or FAO Member States. The labour intensive aspects of tsetse fly mass rearing were reviewed and it was found that the required workload to rear a 100 000 female tsetse fly colony could be reduced from 190 to 140 person-hours per week. The cost of the in vitro blood diet could also be reduced by 80%. Relevant quality control procedures were successfully tested and enforced and more reliable climate control systems, suitable also for projects in Africa, were developed and installed.

Tsetse genetics and related studies

A consultants meeting, held in Vienna in October, assessed the status and prospect of tsetse genetics and molecular biology techniques on tsetse/trypanosomiasis control and eradication. It was recommended that research be conducted (a) to develop genetic and molecular approaches to be used to aid in the separation of male and female tsetse flies (sexing), (b) to carry out a genetic and molecular analysis of the tsetse genome, (c) to determine the genetic factors

Tsetse genetics and related studies (cont.)

involved in vector competence for the transmission of trypanosomes, and (d) to develop recombinant or transgenic tsetse. Another recommendation was that ecological models of tsetse populations and genetic control methods be integrated as a research and decision tool in large control programmes.

Transfer of area wide tsetse eradication technology using SIT

Further progress was achieved in combating tsetse flies in Zanzibar, United Republic of Tanzania. Improved methods for ecological monitoring of the target tsetse fly species were developed; the fly production centre in Tanga, United Republic of Tanzania, provided sexually sterile males in sufficient numbers and quality to considerably reduce the population size in a dense test forest system. Plans are being made to expand the Tanzanian project into a full scale eradication programme starting in mid-1993.

In central Nigeria, laboratory and field activities continued to prevent the reinvasion of tsetse flies into an area previously freed of the pest. In Mali, a series of tests were completed with the aim of developing suitable procedures to transport sterile males from a mass rearing facility in Burkina Faso to the release site in Mali. Preparatory entomological work was pursued in Ghana and Uganda on tsetse fly populations earmarked for future autocidal control using sexually sterile tsetse flies from a mass rearing facility.

Development of radiation induced F-1 sterility for control of Lepidoptera pests affecting major crops

Caterpillars belonging to the order Lepidoptera are very destructive pests of many crops. These species have proved to be difficult to control by means of SIT because they are very radiation resistant and because they are much more difficult to mass rear than flies. However, the radiation resistance of these pests is being used to good advantage in the F-1, or inherited sterility, technique. A new programme that seeks to implement the combined use of natural enemies of the diamondback moth and inherited sterility is being developed in Malaysia. A new CRP approved in 1992 on the evaluation of population suppression by irradiated Lepidoptera and their progeny will seek to apply the available technology to local situations and pests in field tests. Several technical co-operation programmes utilizing this technique are in operation in Cuba, Indonesia, Malaysia, Mauritius and the Syrian Arab Republic.

Isotope aided molecular biology and genetic engineering

A Research Co-ordination meeting for a CRP on genetic engineering technology for the improvement of SIT was held in Vienna in October to discuss developments in genetic engineering and biotechnology aimed at the manipulation of insect pests. The major problem remains the inadequacy of transformation systems. Progress is being made and the problem may be solved in the near future for certain species.

Eradication of the screwworm from North Africa

The SIT eradication programme in the Libyan Arab Jamahiriya, initiated in 1990, has been successful in eradicating the screwworm fly from North Africa. The current situation is even more encouraging. The last case of animals infested with screwworms was in April 1991. Intensive surveillance of animals in the country continued throughout 1992 and no additional cases of screwworm infested animals were found.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Laboratory and field evaluation of genetically altered medflies for use in sterile insect technique programmes	1993	11
1989	Development of practices for area wide tsetse eradication or control with emphasis on the sterile insect technique	1994	13
1989	Genetic engineering technology for the improvement of the sterile insect technique	1994	7

CRPs established in the current year

Subject	No. of years	Participating institutions
Evaluation of population suppression by irradiated Lepidoptera and their progeny	5	19

Training courses and seminars held

Course name	Location	No. of participants	Duration
FAO/IAEA interregional course on the use of radiation and isotopes in insect control and entomology	USA	21	6 weeks

Publications

Series and No.	Title
Technical Reports Series No. 336	Training manual on the use of nuclear techiques in insect research and control
IAEA-TECDOC-634	Tsetse control, diagnosis and chemotherapy using nuclear techniques
Newsletter	Insect and pest control newsletter, No. 47

Agrochemicals and residues

Monitoring pesticide residues in food and the environment

It has been shown that various current practices for the extraction and refining of vegetable oil can reduce pesticide residues in the product. For example, gamma and beta HCH residues are almost entirely eliminated from rice bran oil by deodorization, while monocrotofos was largely removed from palm oil by degummification and bleaching. Further work will seek to identify processes that are both appropriate for preparing the oil in question and also effective at removing the pesticides most likely to be in that particular oil.

Work on the effects of organochlorine insecticides on flora and fauna in Africa was restricted by drought in several participating countries. The first year's results suggest that while effects on non-target species may have occurred in many cases, lindane generally increased maize yields. However, it is too early to draw inferences.

As a first step in establishing an analytical quality control programme for pesticides, participating institutions in the DDT and organochlorine insecticide CRPs and some laboratories receiving technical co-operation support were asked to take part in an interlaboratory comparison. The results available so far cover a two- to four-fold difference, confirming the need for such a programme.

In support of the flora and fauna project, the metabolism of endosulfan in carabid beetles was studied. The results indicate that the beetle can metabolize sublethal doses of endosulfan to endosulfan diol and endosulfan sulphate. Some of the insecticide was also excreted. A study of the metabolism of DDT in the beetle is in progress.

Laboratory activities

The Agrochemicals Unit of the Agency's Laboratory at Seibersdorf provided 24 person-months of training to fellows in the use of radioisotope techniques in research on agrochemicals. The staff of the Unit participated in research in support of CRPs on development of improved formulations of pesticides utilizing nuclear techniques and the effects on flora and fauna from the use of organochlorine pesticides on the African continent. Analytical quality assurance services were also provided for two CRPs. In addition, pesticide formulation samples from Yemen and Somalia were analysed as a service to the FAO Plant Protection Service.

Controlled release formulations of the herbicide thiobencarb which released the herbicide more slowly than a commercial formulation were developed. In addition to reducing toxicity to rice seedlings and fish, these formulations reduced loss of the herbicide by evaporation and photodecomposition. The results were published in the journal *Pesticide Science*.

Research continued on insecticide formulations for tsetse fly targets and several new oil based formulations were prepared and tested. Some of the work was done in collaboration with the University of Bristol, the United Kingdom. A paper on this work was published in *Pesticide Science*. In other experiments, the loss of deltamethrin from targets exposed to the weather was much less in oil based than in oil free formulations. Field tests to compare tsetse fly targets treated with a commercial formulation and oil based formulations prepared in the Agency's Laboratory were conducted in Ghana, Kenya and Zanzibar, and the United Republic of Tanzania.

Laboratory activities (cont.)

Work began on a study of the toxicity to different species of tsetse flies of target screens with deltamethrin and other insecticides. Results were published which show that deltamethrin isomerizes to less toxic epimers when dissolved in lower alcohols, but not in solvents such as hexane, toluene and higher alcohols.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of controlled release formulations of pesticides utilizing nuclear techniques	1993	13
1989	Radiotracer studies of the behaviour of DDT in tropical environments	1994	13
1989	Radiotracer studies to reduce or eliminate pesticide residues during food processing	1994	11
1990	Adverse effects on flora and fauna from the use of organochlorine pesticides on the African continent	1995	22
1991	Development of procedures to stabilize acaricides in livestock dips and of simplified methods to measure their concentration using nuclear techniques	1996	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Use of isotopic tracers in studies of herbicide performance on grasses and sedges	5	9

Publications

Series and No.	Title
Technical Reports Series No. 329	Laboratory training manual on the use of nuclear and associated techniques in pesticide research

Food irradiation

Control of the food irradiation process

A training manual for the operation of food irradiation facilities was prepared. Another manual for the inspection of facilities is in preparation. The ICGFI adopted an international inventory of authorized food irradiation facilities in order to promote the proper control of food irradiation processing and the acceptance of irradiated food in trade. It also finalized a model certificate for the irradiation treatment of food. The question of the control of irradiated food moving in trade through proper process control and other measures is being pursued in collaboration with the Codex Alimentarius Commission.

Demonstration of techno-economic feasibility of food irradiation in developing countries

Through technical assistance programmes, support was given to Bangladesh, Ghana and Viet Nam for building demonstration irradiators for treating food and sterilizing medical supplies. Expert assistance on the regulatory aspects of food irradiation was provided to Malaysia, Pakistan, the Philippines and Sri Lanka and on the process control of food irradiation to China.

Demonstration of the effectiveness of irradiation to reduce foodborne parasites and pathogens

A CRP on food irradiation to control the infectivity of foodborne parasites was completed and a technical report on the results of the research will be published. The results confirmed that irradiation would be an effective method of controlling foodborne parasitic diseases. To this end, the parameters of the irradiation treatment were established. Efforts are being made to continue work in this field in co-operation with WHO (PAHO). An expert consultation meeting was jointly organized with PAHO in October. The aim was to draw up an action plan to use irradiation as a public health intervention measure for controlling foodborne diseases in Latin America and the Caribbean.

General activities

Databases were maintained in several subject areas and, in addition, a computerized database was developed for the legal authorization of food irradiation processing in various countries. Steps were taken to consolidate all scientific data on food irradiation in collaboration with the United States National Agricultural Library. Information on a variety of aspects of food irradiation technology was provided on request to Member States of the Agency, FAO and WHO.

The Agency supported the work of the ICGFI and its 9th meeting by providing secretariat services. The ICGFI continued to provide information and advice to the Agency, FAO and WHO and their Member States in the areas of safety assurance of the irradiation process and of irradiated foods, techno-economic feasibility, training, regulatory control of food irradiation and public information. The ICGFI Network for Training on Food Irradiation (INTFI), which had taken over the functions of the previous International Facility for Food Irradiation Technology (IFFIT), continued to provide training on food irradiation. In an effort to provide member countries with accurate information on food irradiation, ICGFI held a seminar on public information jointly with the CEC and republished, in booklet form, 14 Fact Sheets on various issues of interest to the public. The Fact Sheets, which were also published in French, Russian and Spanish, were widely disseminated.

General activities (cont.)

Resolution GC(XXXVI)/RES/588, adopted by the regular session of the General Conference, directed the Agency to prepare, in consultation with other United Nations organizations, a detailed project proposal for the practical utilization of food irradiation in developing countries, for consideration by the Board of Governors in 1993. Efforts are being made to meet the requirements of this resolution.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Food irradiation in the Middle East and Europe	1993	12
1989	Application of irradiation techniques for food processing in Africa	1993	11
1990	Analytical detection methods for the irradiation treatment of foods	1995	21
1990	Irradiation, in combination with other processes, for improving food quality	1995	19
1989	Food irradiation process control and acceptance in Asia	1993	16

CRPs established in the current year

Subject	No. of years	Participating institutions
Irradiation as a quarantine treatment of mites, nematodes and insects other than fruit fly	5	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional workshop for Latin America on the techno-economic feasibility of food irradiation	Mexico	27	10 days
Seminar on the harmonization of legislation on food irradiation in Asia and the Pacific	Malaysia	54	5 days
Workshops on the regulatory control of food irradiation	Argentina Hungary	15 15	3 weeks 3 weeks
Workshop on the use of irradiation and refrigeration to ensure the hygienic quality of food	USA	18	2 weeks

Publications

Series and No.	Title
Panel Proceedings Series	Asian regional co-operative project on food irradiation phase II: Technology transfer
Panel Proceedings Series	Use of irradiation as a quarantine treatment of food and agriculture commodities
IAEA-TECDOC-639	Irradiation of spices, herbs and other vegetable seasonings: A compilation of technical data for its authorization and control
IAEA-TECDOC-642	Harmonization of regulations on food irradiation in the Americas
IAEA-TECDOC-651	Latin American regional co-operative programme on food irradiation

HUMAN HEALTH

Programme overview

The programme on human health addressed issues where nuclear techniques are especially efficient and cost-effective in the prevention, diagnosis, prognosis and treatment of diseases, or in the analysis of health problems related to the environment such as pollution and the availability of nutrients. Specifically designed in consultation, and in some cases in collaboration, with WHO, it emphasized techniques suitable for the study and management of communicable diseases, nutritional problems, and cancer, heart and brain diseases, all of which are of special significance for developing countries. Projects in 1992 continued to focus on strengthening indigenous skills and capabilities not only in methodology, but also in reagent production and in maintenance, repair and upgrading of medical nuclear instruments. An IAEA/WHO Interagency Consultation Meeting was held in Geneva to review the activities performed in areas of collaboration during the last two years and to discuss collaborative projects for the biennium 1993-1994.

New initiatives and concepts were set in motion in order to improve the efficiency of the programme:

- *The concept of quality control of instruments and procedures was expanded to cover the more significant area of quality assurance, including quality control of all items and steps involved in the clinical process, from the selection of patients, instruments and procedures to the final clinical outcome.*
- *Problems of communication with potential counterparts have been alleviated by creating a symbiotic association with national, regional and international medical societies to build up a network for the exchange of information.*
- *Steps were taken to improve the maintenance and repair services of nuclear medicine instruments offered by manufacturers in the RCA region. An Agency co-ordinated union of gamma camera end-users and major manufacturers was created.*
- *Remote training courses were designed to train and accredit nuclear medicine technologists in order to solve the issue of insufficient manpower in the RCA region. This is the first time that this educational tool has been applied in the programme of human health as well as the first occasion on which the Agency has addressed the needs of those who are directly responsible for the conduct and clinical quality of such studies.*
- *Special steps were taken to address the issue of the high cost and sophistication of commercially available instruments which render them unsuitable for the needs of developing countries:*
  - *Negotiations are progressing for the production in Egypt of a robust ^{60}Co gamma teletherapy machine designed in Hungary for provision to developing countries;*
  - *Commercial firms have been approached to convince them of the need for a simple, low cost analog gamma camera suitable for developing countries; and*
  - *Two technical contracts have been awarded for the development of a low cost interface to link analog gamma cameras with personal computers, as well as the appropriate software for the acquisition, storage, display, processing and analysis of nuclear medicine images. The interface will be used in upgrading more than 500 analog gamma cameras in developing countries, shifting from static analog imaging to dynamic imaging with digital analysis and quantification. It will also be the basis for the first attempt at international standardization of nuclear medicine imaging procedures.*
- *Knowledge accumulated in radiation biology in the development of predictive assays of tumour response to radiation was used for effectively selecting the optimum treatment modality (radiation, surgery, chemotherapy or their combination) during cancer management.*

- The IAEA/WHO thermoluminescent dosimetry (TLD) service was extended from ^{60}Co gamma teletherapy units to high energy X rays emitted by medical accelerators. The alanine/ESR dosimetry system was introduced at the Agency's Laboratory at Seibersdorf as a reference service to Member States for high dose dosimetry.
- The Agency played a major role in the foundation, in 1992, of the Ibero-American Board for the Certification of Nuclear Physicians in Latin America, Portugal and Spain. The Statutes of the Board consider mechanisms for re-certification every five years in order to maintain the quality of clinical practice in the discipline and stimulate the interest of physicians in new developments.
- A tripartite Memorandum of Understanding between the Agency, UNEP and the Intergovernmental Oceanographic Commission (IOC) of UNESCO was signed to strengthen interagency co-operation in the assessment, prevention, control and abatement of marine pollution. The document sets out a strategy for co-ordinated planning and implementation of activities and provides a practical framework for enhancing co-operation. The approach used closely follows the recommendations of UNCED.

The subjects for new CRPs and training courses showed a new trend in 1992 by addressing the most recent advances in the field, such as detection of tumour markers in blood and immunoscintigraphy with radioactive monoclonal antibodies in diagnosing cancer; application of the polymerase chain reaction and radioactive probes in the diagnosis of communicable diseases, and use of single photon emission computerized tomography (SPECT) in heart and brain diseases. The experience gained and infrastructure created by previous CRPs in the field of radioimmunoassay (RIA) were used in 1992 to launch national screening programmes for the cost effective detection of hepatitis B infection and neonatal hypothyroidism, both prevalent in extensive areas of the developing world. Development of software for external quality assessment of RIA was an important milestone in these activities.

A scientific afternoon during the regular session of the General Conference provided the opportunity to remind decision makers and senior government officials from Member States of the importance of nuclear medicine in the prevention of disease and promotion of health and the significance of cancer control by radiation therapy.

A shortfall in financial resources during the year made necessary certain programmatic changes by way of deferment of some of the components and reduction in the amount and number of research contracts. In particular, CRPs on screening programmes for viral hepatitis (global coverage), dynamic studies of the heart and brain, and quality assurance programmes for radiation therapy dosimetry in developing countries had to be deferred. Another CRP, on neonatal hypothyroidism in the Latin American region, could be started only late in 1992.

Nuclear medicine

Quality control and preventive maintenance of nuclear and related equipment in medicine

The interaction between the Agency and potential medical counterparts was enhanced through an informal association with national and regional societies and with the World Federation of Nuclear Medicine and Biology, including active co-participation in their meetings. The Agency played a significant role in the foundation of the Ibero-American Board for the Certification of Nuclear Physicians during the 12th Congress of the Latin American Association of Societies of Nuclear Medicine and Biology held in Madrid, Spain. Advantage was also taken of the 5th Asia and Oceania Congress of Nuclear Medicine and Biology in Jakarta and Bali, Indonesia, to hold the first Agency Task Group meeting on Regional End-users Union of Nuclear Medicine Instruments as well as a co-ordination meeting on future training needs in RCA nuclear medicine and related projects from 1993 to 1997. As a result, it was decided to start the Regional End-users Union with a pilot project including 4 countries, 282 gamma cameras and 8 manufacturers, with the co-ordination of the Agency, to improve the maintenance and repair services offered by firms within the region, and to develop computerized management of preventive maintenance of nuclear medicine equipment. It was also decided to launch a pilot scheme for the training of nuclear medicine technologists within the RCA region through multimedia distance-learning techniques. On the occasion of the Congress, discussions were also held with the COST-B2 Management Committee of the European Community on the co-ordinating role of the Agency for an interlaboratory comparison in developing countries with the software phantom for nuclear medicine imaging that has been designed by COST-B2.

Enhancing the capability of developing countries to perform dynamic functional studies of the heart and brain

A consultants meeting was held in April 1992 to formulate the strategies to develop a computer interface which will link gamma cameras with personal computers. Consultants from Cuba, India, Mexico and the United Kingdom took part in the meeting. As a result, technical contracts were awarded to institutions in India and the United Kingdom to build an interface prototype and to design the relevant software for image acquisition, storage, processing, analysis and display.

Screening for neonatal hypothyroidism

Neonatal hypothyroidism formed the subject of a CRP which was completed in 1992. This programme succeeded in establishing the techniques needed for the implementation of screening programmes in the countries involved. The results were published in the scientific literature.

Diagnosis of communicable diseases

The CRP on immunodiagnosis of malaria was terminated. The results showed that anti-sporocyte antibody levels could be used as serological markers to monitor malaria transmission and the efficacy of control measures.

Cost effectiveness of nuclear and non-nuclear diagnostic procedures

The results of a CRP concluded in 1992 on a comparison of nuclear and non-nuclear modalities of liver imaging will be discussed at a final Research Co-ordination meeting in January 1993 with publication of an atlas of liver imaging. Another CRP on radioaerosol inhalation imaging in respiratory disorders will result in the publication of an atlas following the final Research Co-ordination meeting in January 1993.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Development and field application of nuclear techniques in malaria research and control (AFRA)	1994	11
1987	Radioaerosol inhalation imaging in the diagnosis of respiratory diseases in developing countries (RCA)	1992	10
1987	Optimization of nuclear techniques for the survey of thyroid function of newborns in areas with endemic goitre	1992	8
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1994	6
1988	Basic care and preventive maintenance of nuclear medicine instruments (RCA)	1992	11
1989	Immunoradiometric assay for malaria detection	1992	7
1989	Evaluation of imaging procedures for diagnosis of liver diseases. Phase II	1992	13
1989	Quality control and preventive maintenance of nuclear related equipment in Africa	1994	8
1989	Quality control and preventive maintenance of nuclear medicine equipment in Latin America	1993	13
1989	Quality control of advanced nuclear medicine equipment in Asia	1993	8
1991	Diagnosis of tuberculosis using ^{32}P labelled DNA probes (RCA)	1994	9
1991	Detection of blood borne diseases using ^{32}P labelled DNA probes	1994	8
1991	Measurement of alpha-feto protein by radioimmunoassay in the discrimination of liver space-occupying lesions	1993	10
1991	Early detection of colonic cancer by immunoscintigraphy using $^{99}Tc^{m}$ labelled anti-carcinoembryonic antigen monocional antibodies	1993	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Establishment of screening programmes for neonatal hypothyroidism based on filter paper blood spot assays for thyroxine and thyrotrophin (ARCAL VIII)	2	15
Screening for viral hepatitis (RCA)	2	14
Qualitative nuclear cardiology	2	8
Nuclear investigations of cerebral functions	2	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on advanced SPECT with emphasis on heart and brain diseases	Italy	31	2 weeks
Regional course on quality control and data processing in radioimmunoassay with emphasis on external quality assurance schemes	Tunisia Algeria Paraguay	23 20 17	2 weeks each
Regional course on recent molecular biology techniques and radionuclide methods for the diagnosis of communicable diseases	Thailand	23	2 weeks
Single photon emission computerized tomography (SPECT): Physics and clinical applications	Thailand	23	2 weeks
National workshop on magnetic particle linked bulk reagents	Thailand	17	3 weeks
Regional course on the use of computers in nuclear medicine	Australia	11	6 weeks
Quality control of gamma cameras	Malaysia	15	1 week
Quality control of advanced nuclear medicine equipment	Thailand	12	1 week
Quality control and single photon emission computerized tomography (SPECT) systems	China	35	1 week

Publications

Series and No.	Title
Special publication	Handbook of nuclear medicine practice in developing countries
Proceedings Series	Developments in radioimmunoassay and related procedures

Applied radiation biology and radiotherapy

Radiation sterilization of medical supplies

Progress in the project on tissue graft sterilization by radiation processing stimulated a review and project formulation meeting for a second phase. During the meeting it was estimated that the cost of indigenous procurement of clinical tissue grafts followed by radiation sterilization in the RCA region is one hundredth of the price of the similarly treated tissue grafts available on the commercial market.

Comparative assessment of mutagenic and carcinogenic effects of radiation and chemicals

A new CRP on the comparative assessment of mutagenic and carcinogenic effects of low level radiation and toxic chemicals released from energy cycles will help provide methodologies for the quantitative evaluation of the potential risk to health imposed by emissions from fossil fuelled energy sources.

Exploration of the stimulation effects of low dose radiation

A Research Co-ordination meeting, held in Kyoto, Japan, in conjunction and in co-operation with the International Conference on Low Dose Irradiation and Biological Defence Mechanisms, improved understanding of the molecular mechanisms involved in the biological effects of low dose and low dose rate radiation and their significance in human health risk assessments.

A new CRP is centred on radiation responsiveness criteria for human tumours as determinants for therapeutic modality planning, and it is in accordance with the continuing goal of improving the status of cancer therapy. As the response to radiation varies according to the type, position and stage of a given tumour, this CRP was designed to clinically validate radiobiological tests of tumour radiosensitivity to be used as predictors of the tumour response for the selection of the optimal treatment regime and modality in each individual. Those tumours which are predicted to be sensitive to radiation would be better treated with radiotherapy, while those identified as relatively resistant to radiation should be considered for another treatment modality (surgery or chemotherapy). It is expected that this new approach will enhance the efficiency not only of radiotherapy but also of other modalities for cancer treatment, helping to improve the overall cancer cure rate.

A consultants meeting was held for the planning of a new CRP aimed at enlarging the remedial scope of innovative quality controlled brachytherapy techniques in the management of cancer.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Microbiological quality control and sterility safety evaluation in radiation sterilization of local medical supplies in Latin America	1994	7
1990	Radiobiological impact of hot beta particles from the Chernobyl fallout: Risk assessment	1993	12
1990	Exploration of the molecular mechanisms of the stimulatory effect (i.e. adaptive response) of low dose and low dose rate radiation	1993	12
1990	Computer assisted planning and dosimetry in radiotherapy of carcinoma of the cervic in the Asia and Pacific Region (RCA)	1993	9
1990	Computer assisted planning and dosimetry in radiotherapy of head and neck cancers	1993	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Comparative assessment of mutagenic and carcinogenic effects of low level radiation and toxic chemicals released from energy cycles	3	6
Radiation responsiveness criteria for human tumours as a determinant for therapeutic modality planning	3	3

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on radiation sterilization of tissue grafts with particular emphasis on quality control	China	20	2 weeks
Industrial sterilization of medical products (process and quality control — sterility assurance)	Turkey	21	1 week
RCA workshop on computer assisted planning and dosimetry for carcinoma of the cervix	India	9	1 week

Dosimetry

Secondary Standard Dosimetry Laboratory (SSDL) network

The biennial meeting of the Secondary Standard Dosimetry Laboratory (SSDL) Network Scientific Committee was organized. An internal report was prepared on the operation and improvement of the SSDL Network and the recommendations on the entire dosimetry programme.

The IAEA/WHO SSDL Network presently includes 65 laboratories and 6 national organizations in 52 Member States, as well as 14 affiliated members (i.e. primary standard laboratories). Another two SSDLs, which have been fully supported, are not yet members of the network. Services continued in the areas of dose intercomparison and assurance, as well as support for technology transfer. Calibrations of 24 secondary standard dosimeters/field instruments with a total of 136 radiation qualities, 1200 reference irradiations for Member States and on-site training for SSDL staff were provided by the Agency's Laboratory at Seibersdorf. A total of 26 technical co-operation projects were handled, providing support for setting up SSDLs and for improving radiation dosimetry at SSDLs.

Dose intercomparison and assurance

The operation of the IAEA/WHO Thermoluminescent Dosimetry (TLD) Service was extended to include medical accelerators in addition to ^{60}Co teletherapy units. Some 340 sets of TLD dosimeters were distributed for monitoring ^{60}Co beams, and 75 sets for monitoring accelerator beams at radiation therapy centres and SSDLs.

The International Dose Assurance Service (IDAS) for radiation processing facilities was continued. The alanine/ESR dosimetry system was fully established and the entire analysis function for IDAS was taken over by the Agency's Laboratory at Seibersdorf. In spite of the change of the producer of the alanine dosimeters and the new evaluation procedure, 49 alanine dosimeter sets were distributed to 13 participating institutions from 12 countries.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Testing of the code of practice for absorbed dose determination in photon and electron beams	1993	9
1988	Development of quality control dosimetry techniques for particle beam radiation processing	1994	9
1989	Performance testing of dosimetry equipment	1993	8
1991	Therapy level dosimetry with alanine/ESR system	1994	5

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional courses on dosimetry calibration procedures	Finland/ Sweden	30	3 weeks
IAEA/PAHO regional course on quality control in radiotherapy	Cuba	72	1 week

Publications

Series and No.	Title
Newsletter	SSDL newsletter, No. 31

Nutritional and health related environmental studies

Isotope techniques in human nutrition research

Work conducted during 1992 (partly in collaboration with WHO) focused on a number of projects relating to micronutrient nutrition. Dietary surveys of essential micronutrients in 16 countries were completed with the analysis of 24 analytes in more than 400 samples; a report is in preparation. Work has also been supported under a CRP on the means to improve iron and zinc nutrition in 11 countries. A database of dietary intake data in 47 countries was completed and published.

With the help of consultants, protocols were prepared for two new CRPs, due to start in 1993. One of these will focus on amino acid requirements and protein-energy interactions in malnourished children suffering from infections; the other will address nutritional and other issues in the aetiology and prevention of osteoporosis (a bone disease affecting about 200 million people worldwide, mainly women).

Applied research on environmental pollution using nuclear and isotopic techniques

Advisory missions on nuclear techniques in health related environmental monitoring and research were carried out in Chile and Uruguay.

A symposium on the applications of isotopes and radiation in conservation of the environment was organized in Karlsruhe, Germany. The presentations made during this meeting showed clearly that nuclear analytical techniques and isotopic tracers have retained some unique advantages in environmental research and monitoring — despite increased competition from non-nuclear analytical methods. Particularly favourable applications include isotopic tracer studies of waste depositories, borehole logging, certification of analytical reference materials and multi-element non-destructive analysis of environmental specimens. However, a number of factors were identified that are hindering the more widespread application of these techniques: insufficient transfer of the relevant technologies to developing countries; lack of standardization in sampling, sample preparation and data evaluation; and lack of public acceptance of nuclear technology in general.

Several relevant examples of important applications of nuclear analytical techniques in the protection of the environment are provided by work carried out in 20 countries under a CRP on environmental pollution associated with solid wastes. This CRP was concluded during 1992 and a report is in preparation. A follow-up CRP on air pollution was expanded to encompass 17 countries; significant progress was made in developing standard procedures for the collection of air particulate matter and for the quality control of the analyses. A new candidate reference material for air pollution studies, lichen, was prepared under contract, and an international intercomparison exercise was carried out.

A CRP on environmental exposure to mercury, conducted in nine countries in collaboration with WHO, provided new evidence of the potential impact of this pollutant in some population groups that are exposed to it through consumption of contaminated fish.

Services to international pollution monitoring programmes

During 1992, a set of techniques was applied by IAEA-MEL in the evaluation of the contamination of two aquatic systems. The first (in collaboration with UNEP, UNDP and the National Research Centre, Cairo) was Lake Manzala, Egypt. The other study (in collaboration with the Equipe Cousteau, the European Bank for Reconstruction and Development and the VITUKI Institute

for Water Pollution Control, Hungary) was a contamination assessment of the Danube River to investigate the status of domestic, agricultural and industrial pollution. The results show the existence of contamination 'hot spots', with a clear gradient of pesticide concentrations from the upper to the lower reaches of the river.

Services to international pollution monitoring programmes (cont.)

As part of its programme of technical assistance to UNEP, scientists from IAEA-MEL conducted an assessment of pollution in the Black Sea and participated in the design of a Global Environmental Facility (GEF) programme for the environmental protection and management of the Black Sea. The work included extensive missions to all the coastal States and support for the preparation of a Ministerial Declaration on the Protection of the Black Sea to be signed in 1993 in Odessa. The GEF programme, with an initial funding of $9.3 million, will include a three year programme supporting capacity building, the development of tools for management (including pollution assessment) and pre-investment activities.

The damage to ecosystems from the spillage of petroleum and the burning of oil wells in Kuwait during the Gulf war was addressed in a publication by IAEA-MEL scientists. The results showed that severe oil pollution was restricted primarily to the Saudi Arabian coastline within approximately 400 km of the spillages and that during the four months following the conflict (and preceding sample collection) the oil had extensively degraded.

Research continued on nuclear and non-nuclear techniques for studying the transfer and fate of pesticides in tropical lagoon systems using radiolabelled compounds. Laboratory 'microcosm' experiments were devised to measure bioaccumulation rates, degradation rates and the persistence of chlorpyrifos, DDT and parathion in marine waters under various environmental conditions. In collaboration with marine scientists from the Mazatlan marine station of the National Autonomous University of Mexico, a major experiment was conducted in a tropical lagoon using large field enclosures containing natural sediments and a variety of local marine species.

Laboratory activities

The Chemistry Unit of the Agency's Laboratory at Seibersdorf continued to provide support for the various CRPs in this subject area and also assisted the IAEA Action Team under Security Council Resolution 687 in its assessment of the environmental potential of Iraq's nuclear activities.

Staff from the Unit provided laboratory training in low level radioactivity separation and measurement techniques to fellows and to scientific visitors in a study of the determination of natural and man-made radionuclides in food chains and environmental samples (approximately 25 person-months).

A programme on the monitoring of accidentally released radionuclides in environmental and food samples, which was initiated in 1986 in response to the Chernobyl accident, was continued. A CRP on rapid instrumental and radiochemical methods was concluded; results will be incorporated in an addendum to the guidebook on the monitoring of accidentally released radionuclides in environmental and food samples, which is in preparation. An analytical method for the determination of ^{129}I was implemented and more than two hundred different environmental samples were analysed for radionuclides, uranium and plutonium. Two intercomparison runs for radionuclides in soil and grass are under way to certify new analytical reference materials.

Laboratory activities (cont.)

Radioisotopes of iodine, particularly ^{131}I ($T_{½}$ = 8 d), have been useful in tracing the distribution process of fission products in the environment because of the high fission yield and distinctive chemistry of this element. However, for times greater than a few weeks after fission, only ^{129}I can be used as an environmental iodine tracer. The Laboratory has recently established a neutron activation procedure which has been applied to environmental materials including samples from the Chernobyl region. Currently, an intercomparison exercise for the determination of ^{129}I is being held. This will result in an evaluation of the capabilities of the various methods, and possibly in the first certified material with a referenced concentration of ^{129}I.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Use of nuclear and nuclear related techniques in the study of environmental pollution associated with solid wastes	1992	22
1988	Applications of stable isotope tracers in human nutrition research	1992	11
1988	Rapid instrumental and separation methods for monitoring radionuclides in food and environmental samples	1992	12
1990	Assessment of environmental exposure to mercury in selected human populations as studied by nuclear and other techniques	1994	9
1990	Isotope aided studies of the bioavailability of iron and zinc from human diets	1994	11
1991	Applied research on air pollution using nuclear related analytical techniques	1996	17

CRPs established in the current year

Subject	No. of years	Participating institutions
Development and selection of analytical techniques and procedures for measuring accidentally released radionuclides in the environment	4	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
Isotope techniques in human nutrition research	India	49	1 week
Analytical chemistry	Monaco Kenya Brazil Thailand Egypt	56	2 weeks each

Publications

Series and No.	Title
Proceedings Series	Applications of isotopes and radiation in conservation of the environment

INDUSTRY AND EARTH SCIENCES

Programme overview

The main areas of activity for the industry and earth sciences programme in 1992 included:

- *Application of nuclear methods for the monitoring and control of environmental pollution;*
- *Assessment and transfer of radiation technology;*
- *Assessment and transfer of nucleonic control systems and radiotracer applications in the mineral industry;*
- *Assessment of water resources, with emphasis on arid and semi-arid regions;*
- *Evaluation of the contamination risk for water resources and of processes of contaminant transport in water bodies;*
- *Exploration of geothermal areas, with emphasis on high enthalpy fluids;*
- *Studies of sediment transport related problems.*

Progress was made in demonstrating the potential of nuclear techniques in conservation of the environment through a series of meetings (such as a symposium on the applications of isotopes and radiation in conservation of the environment, which was held in Karlsruhe, Germany, in March), consultants services and CRPs. Increased emphasis was placed on training courses, workshops and seminars.

The programme on water resources assessment continued to promote the use of isotopes for hydrological research. In particular, the ongoing activities to determine the isotopic composition of precipitation in a global network and the Isotope Hydrology Laboratory's analytical and intercalibration services fostered the development of isotope methodologies as practical hydrological tools worldwide. The Agency also continued to respond to the needs and problems related to field studies in countries which are not equipped to use isotope techniques.

Increased emphasis was placed on the assessment of water resources in arid and semi-arid regions and an evaluation was made of the replenishment of groundwater resources currently being investigated within the framework of technical co-operation projects in various Member States in the Middle East, Africa and Latin America. Information on the rate of replenishment is essential for rational development and management of groundwater resources in these countries.

Sources of groundwater pollution and salinization were identified and pollutant migration was studied as a part of technical co-operation projects in several Member States.

Artificial and environmental isotope methods were used, the former to trace the fate of reinjected fluids (in Costa Rica and El Salvador), and the latter to assess the characteristics of geothermal fluids at depth during exploration of geothermal areas (in particular, in Indonesia and the Philippines).

Studies of sediment transport related problems were carried out in several Member States. These studies are related to the maintenance of navigation channels in estuarine areas or to siltation problems of reservoirs.

Owing to a shortfall in financial resources as a result of reductions in the budget, some tasks had to be cancelled or deferred in the areas of radiation technology, surface water studies and isotopic measurement intercalibration.

Industrial applications

Assessment and transfer of radiation technology

A symposium on the applications of isotopes and radiation in conservation of the environment was held in Karlsruhe, Germany, in March. The meeting reviewed the status and trends in the applications of radiation, radioisotopes and nuclear methods of analysis in the monitoring and control of environmental pollution and in reducing emissions of environmentally toxic substances. Many different applications of nuclear technology, such as flue gas purification, radiation processing of liquid and solid wastes, radiotracer studies and nuclear analytical techniques and their applications, were reviewed in detail. It was concluded that nearly all the techniques under consideration have considerable potential for future application on a much larger scale.

The results of a CRP on radiation processing of combustion flue gases and the operation of a demonstration facility in Poland contributed to the optimization of the electron beam process for flue gas purification, particularly in enhancing energy efficiency, by-product recovery and a reduction in the formation of toxic gases and their emission. The transfer of the technology to developing countries was also pursued.

Manpower development for non-destructive testing

Under a CRP on nuclear methods in monitoring wear and corrosion in industry, work was initiated in the following areas: evaluation of the thin layer activation method for the monitoring of wear and corrosion (erosion), the technology of irradiating machine parts in charged particle accelerators, nuclear data on thick target yields, the depth distribution of radionuclides, the influence of charged-particle irradiation on the physical and chemical properties of objects and the fast recoil technique as applied to metals, plastics and ceramics.

Assessment and transfer of nucleonic control systems for the mineral industry

An ongoing CRP on nuclear techniques in the exploration of coal made substantial progress in the analysis of coal resources in China, Indonesia, the Islamic Republic of Iran, Poland, Turkey and Viet Nam with respect to important environmental pollutants, such as toxic heavy metals, radioactivity, sulphur content and total ash content. Progress was made in demonstrating the potential of low cost nucleonic techniques, such as off- and on-line analysis based on the natural radioactivity of coal, X ray and low energy gamma ray backscattering and attenuation techniques for controlling the quality of coal, especially from mines with low output (i.e. less than 0.5 million tonnes per year).

A CRP on the application of nuclear techniques for environmental preservation in resource extraction and processing made progress in the study of important applications, such as in situ grade evaluation, selective mining and optimization of coal blending operations. These techniques have the potential to establish least disruptive mining methods, which in turn will ensure minimum environmental damage.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Radiation processing of combustion flue gases	1993	9
1988	Radiation processing technology applications in bioengineering	1994	10
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1993	6
1989	Nuclear techniques in exploration and exploitation of coal: On-line and bulk analysis and evaluation of potential environmental pollutants in coal and coke	1994	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of nuclear techniques for environment preservation in resource extraction and processing	3	7
Nuclear methods in monitoring of wear and corrosion in industry	3	5
Nuclear techniques for the evaluation of healing pathways of pollutant damage in the environment	3	10
Stability and stabilization of polymers under irradiation	3	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
Course on non-destructive testing and evaluation in nuclear power plants	Rep. of Korea	12	3 weeks
First meeting of national co-ordinators for ARCAL XVI, industrial applications	Uruguay	17	1 week
National course on industrial radiation sterilization — compatibility of materials	Turkey	20	1 week
National course on industrial radiation sterilization — quality control	Turkey	15	1 week
National seminar on industrial radiation sterilization	Turkey	60	1 day
National seminars on radiation technology	Mexico Paraguay Brazil Argentina	50 20 100 60	2 days 2 days 2 days 2 days

Training courses and seminars held (cont.)

Course name	Location	No. of participants	Duration
Regional course on characterization of materials using low and medium flux reactors	China	13	3 weeks
Regional course on safe operation of industrial radiation facilities	Ecuador	22	2 weeks
Regional workshop on nucleonic control systems in the steel industry	China	15	4 days
Workshop on image processing in materials science and in non-destructive testing	India	17	12 days
Workshop on industrial application of radiation and radioisotopes	Saudi Arabia	26	26 days
Workshop on regulations in industrial sterilization	Hungary	12	1 week
Workshop on safe operation of industrial radiation facilities	Czechoslovakia	15	2 weeks

Publications

Series and No.	Title
Training Course Series No. 3	Industrial radiography: Manual for the syllabi contained in IAEA-TECDOC-628

Development of water resources

Development of new methods for the assessment of water resources with isotope techniques

A regional technical co-operation project is being implemented in the Middle East which seeks to transfer technology to Member States by setting up analytical facilities and carrying out demonstration studies for water resources assessment, development and management. The isotope field studies implemented in each country are related to groundwater, which is the major source of water in most arid and semi-arid regions. The objectives are to establish the origin and age of groundwater and to assess the occurrence of modern recharge.

Hydrological studies related to water resource investigations were initiated in several areas of the Peruvian 'Altiplano' (above 4000 m elevation) using environmental and artificial tracers. It is hoped that these studies will contribute to a better understanding of the origin, age and hydrological behaviour of a number of water bodies.

On the basis of isotope analyses and hydraulic conductivity, climatological and hydrological data, groundwater recharge was evaluated for the Makutapora Basin, the most important source of water for Dodoma City, United Republic of Tanzania. It was concluded that the present rate of groundwater withdrawal was within the safe yield of the Makutapora aquifer system.

The groundwater dynamics of the overexploited aquifer of Wadi Bieh, Dubai, United Arab Emirates, was studied and the recharge from water impounded in a nearby artificial reservoir estimated.

Within the framework of the ARCAL XIII project, field activities have continued in Argentina (La Plata aquifer), Bolivia (Cochabamba aquifer), Brazil (Chapado do Aripe and Parana basin), Chile (Azapa Valley and Salar del Huasco aquifer), Colombia (Sabana de Bogota aquifer), Costa Rica (Tempisque Valley), Cuba (Jaruco-Aguacate karst aquifer), Ecuador (Rio Guayas Valley and Chacras-Huaquillas), Guatemala (Atitlan Lake and Guacalate basin), Mexico (La Laguna and Saltillo-Monterrey aquifer), Peru (Lima aquifer), Uruguay (Las Piedras aquifer) and Venezuela (Lake Valencia). In many cases, the studies have produced information not attainable using other techniques related to groundwater dynamics, the connection between surface water and groundwater and groundwater pollution.

During the exploration of geothermal areas, artificial and environmental isotope methods were used, the former to trace the fate of reinjected fluids (in Costa Rica and El Salvador), and the latter to assess the characteristics of geothermal fluids at depth. In particular, in Indonesia and the Philippines, geochemical and isotopic exploration studies were carried out in many areas with geothermal potential.

Neutron activation and X ray fluorescence (XRF) analyses were used to identify the origin and composition of sediments in rivers in the Dominican Republic and in Ecuador, and nuclear techniques were used to determine the amount of sediment transported by rivers. These studies will help to understand the siltation process of reservoirs in the two countries.

Studies on bottom sediment transport using radioactive tracers were initiated in Haiphong Harbour (Viet Nam) and in the Magdalena River (Colombia); these will help to improve the planning of dredging works and the design of navigation channels.

Study of water resources in Africa

A technical co-operation regional project that was concluded in 1992 had the aim of fostering the application of isotope techniques to various hydrological problems typical of Sahelian countries. Water balance terms (recharge and evaporative losses), water origin and age, and the origin of piezometric depressions were assessed for groundwater systems in Cameroon, Mali, Niger and Senegal. This information can help in planning for the exploitation of these resources. Determinations of wadi discharge and sediment transport were also carried out.

Environmental investigations with isotope techniques

A CRP on nuclear techniques in the study of pollutant transport in the environment was completed. This CRP used field and laboratory experiments combining nuclear and conventional techniques to investigate the natural processes governing pollutant transport in water bodies. Noteworthy results were achieved, especially on pollutant interaction with the aquifer matrix or with sediments.

Investigations based on the use of tracers (mainly tritium) to model tracer transport in geological formations contributed to the optimization of the lixiviation of copper dumps at the Chuquicacamata copper mine in Chile. This has a bearing on groundwater protection.

The hydraulic connection between surface water and groundwater was studied in Mauritius using artificial tracers. At two sites it was found that groundwater used for drinking water was endangered by surface water contaminated by industrial wastes.

A study of the Sechura and Tumbes aquifers located in the northern part of Peru was completed. Dissolution of salts present in the aquifer matrix appeared to be the major cause of groundwater salinization.

A review of data from the IAEA–WMO network on isotopes in precipitation was completed. Technical Reports Series No. 331, Statistical Treatment of Data on Environmental Isotopes in Precipitation, was published. It was based on about 100 000 items of data accumulated so far on ^{18}O, deuterium and tritium. The migration of the database on isotopes in precipitation from the mainframe computer to the new personal computer based system was completed, simplifying and speeding up data elaboration.

A project dealing with the Amazon Basin was recently completed. The Agency supervised the subproject on the hydrological cycle. The contribution of the project to a better understanding of the largest tropical forest ecosystem on the Earth was substantial.

In view of the present environmental crisis in the Black Sea, a consultants meeting was held at the IAEA-MEL in Monaco. The meeting provided guidelines for further research and defined the scope and objectives of a new CRP on the application of tracer techniques in the study of processes and pollution in the Black Sea. Natural and anthropogenic radionuclides and environmental isotopes can provide new information on water dynamics and the biogeochemical cycles of the Black Sea. This information will be useful in predicting the impact of marine pollution in this water body and improving regional environmental management.

A new CRP on continental isotope indicators of palaeoclimate was initiated. The programme is focused on the study of climatic fluctuations over continental areas during the last glacial/interglacial cycle, for which environmental isotopes are a powerful tool. So far, 13 scientific teams from 12 Member States have expressed interest in participating in this study.

Analytical and intercalibration services

Efforts to set up radiocarbon laboratories in Ecuador, Nicaragua and Uruguay were initiated. These laboratories will help to meet the growing demand for radiocarbon analyses in Latin America. Assistance to upgrade capabilities for chemical analyses of water samples (to run in parallel with isotope analyses) was given to laboratories in Guatemala, Nicaragua and Senegal. Four fellows from three Member States (Italy (2), Jordan, the Philippines) were trained in isotope measuring techniques.

The Isotope Hydrology Laboratory organized the shipment of approximately three hundred samples of stable isotope reference and intercomparison materials. An intercomparison test of five materials for ^{13}C and ^{18}O isotope analyses was started. Two of the samples distributed were provided by the United States National Institute of Standards and Technology.

Approximately 4000 water samples were analysed for deuterium, 3800 for ^{18}O, 1250 for tritium, 100 for ^{14}C and 160 for ^{13}C, and 2400 chemical determinations were performed on 385 water samples. This activity was carried out in support of technical co-operation projects, research contracts and regional programmes and for the global network to monitor the isotopic composition of precipitation.

Co-operation with other United Nations organizations

A consultants meeting on isotope techniques in lake investigations was organized in Vienna within the framework of the UNESCO International Hydrological Programme. The latest isotope techniques in lake studies were reviewed, research needs identified and recommendations formulated for the initiation of a CRP on the use of isotopes in studying water pollutant dynamics in lakes.

A UNESCO–CEC–IAEA workshop on the hydrological impact of nuclear power plant systems was held in September at UNESCO Headquarters in Paris. The workshop was organized within the framework of the UNESCO programme devoted to the consequences of the Chernobyl nuclear accident. The purpose of the workshop was to review the existing knowledge of radionuclide transport in the hydrological cycle and identify avenues to disseminate this information to scientists, operators and decision makers in developed and developing countries.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Nuclear techniques in the study of pollutant transport in the environment	1992	13
1990	Isotopes and geochemistry in geothermal exploration in Africa, Asia and the Pacific, and the Middle East	1993	11
1990	Mathematical models for quantitative evaluation of isotope data in hydrology	1993	10
1991	Isotope variations of carbon dioxide and other trace gases in the atmosphere	1994	13

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of tracer techniques in the study of processes and pollution in the Black Sea	3	13
Use of nuclear techniques in palaeoclimatology — continental isotopic indicators of palaeoclimate	3	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
National workshop on isotope applications in water and geothermal resources	Ethiopia	52	2 weeks
National workshops on the application of isotope and geochemical techniques in geothermics	Indonesia Ethiopia	42 31	2 weeks 2 weeks
Regional course on the use of isotope techniques in environmental studies of the hydrosphere and atmosphere	Brazil	18	4 weeks

Publications

Series and No.	Title
Proceedings Series	Isotope techniques in water resources development
Panel Proceedings Series	Isotopes of noble gases as tracers in environmental studies
Technical Reports Series No. 331	Statistical treatment of data on environmental isotopes in precipitation
IAEA-TECDOC-641	Geothermal investigations with isotope and geochemical techniques in Latin America

PHYSICAL AND CHEMICAL SCIENCES

Programme overview

The implementation strategy adopted during the year in the physical and chemical sciences programme placed greater emphasis on the establishment of nuclear and atomic databases required for fusion reactor technology, radiotherapy and nuclear geology, provided more support to regional schemes for the repair of equipment and the supply of spare parts, placed greater emphasis on calculational requirements for research reactor performance analysis, and gave greater support to local capabilities for the production of new and more sophisticated radiopharmaceuticals.

The main areas of focus in the 1992 programme included:

- *Data centre management, co-ordination and services;*
- *Establishment of improved nuclear data sets for fission and fusion reactor technology;*
- *Establishment of data libraries of atomic and material property data for use in fusion reactor technology;*
- *Maintenance of nuclear instrumentation and development of nuclear spectroscopy software;*
- *Optimization of research reactor operation, utilization and management;*
- *Production of new radiopharmaceuticals and implementation of analytical quality control.*

The Agency's co-ordination of national and regional data centres for nuclear and atomic data continued, ensuring that data measured and evaluated in one country are made available quickly and efficiently to scientists and engineers in all Member States. Improved data centre services are now offered through the first version of the on-line Nuclear Data Information System (NDIS).

Progress was achieved in the field of neutron reaction data for neutron transport calculations and other applications, with five major databases available from the Agency.

In the field of nuclear instrumentation, the capabilities of analytical laboratories, mainly in the developing countries, were improved by training the local technical staff. Technical documents and laboratory manuals on nuclear instrumentation and interfacing were updated and published.

A new module for fast neutron activation analysis was developed and major updates of software for SPEDAC, the transfer and reformatting of spectra program, were implemented.

The 1992 programme at the ICTP encompassed a range of activities that included research, high level training courses, training at Italian laboratories, conferences, workshops and topical meetings. In addition, the Centre developed an advanced training programme leading to a diploma after one year of study in high energy physics, condensed matter physics and mathematics.

Agency assistance in improving the utilization of research reactors for fundamental and applied research continued. To enhance capabilities for analysing reactor performance, new computer codes were developed and mainframe computer codes were adapted for use with personal computers. Training courses and workshops were organized for manpower development. The research reactor database was maintained and updated.

In chemistry, the main focus of activities was to strengthen the capabilities of Member States in the production of high quality medical radioisotopes, radiopharmaceuticals, in vivo diagnostic kits, radioimmunoassay/immunoradiometric assay reagents and assay procedures. Increased emphasis was placed on expanding the applications of advanced radiopharmaceuticals of $^{99}Tc^{m}$ for functional studies of the heart and brain and for SPECT imaging, and labelled monoclonal antibodies for immunoscintigraphy.

A shortfall in financial resources available to the programme resulted in the deferral or cancellation of a number of tasks in the areas of data centre services, intercomparison and validation of nuclear model codes, development of reference nuclear and atomic databases, maintenance of nuclear instrumentation, assessment of the potential use of accelerators in materials analysis and production of new radiopharmaceuticals and Tc generators from low specific activity ^{99}Mo.

Nuclear and atomic data for applications

Data centre management, co-ordination and services

Activities in this area have the objective of providing nuclear scientists in Member States with reliable and up to date nuclear data libraries as required for applications. Networks of national and regional data centres continue to be co-ordinated in the fields of neutron nuclear data (6 centres), charged particle nuclear data (5 centres), photonuclear data (3 centres), nuclear structure and decay data (18 centres), as well as a network on atomic and molecular data for fusion devices (15 centres), in order to compile and exchange nuclear and atomic data worldwide in internationally agreed upon computer file formats. The BROND-2, CENDL-2, ENDF/B-6, JEF-1, and JENDL-3 databases were checked, documented and made available to scientists in Member States. The increased size and accuracy of the available data files required further development and testing of the related data processing computer codes.

The Agency now offers on-line access to the Nuclear Data Information System (NDIS). It is a 1 gigabyte database installed on the Agency's new VAX computer and contains numerical nuclear physics data files describing the interactions of radiation with matter. Manuals and documentation for the different files and formats are available upon request. Instructions on how to access NDIS are included in the quarterly publication *IAEA Bulletin*. The software for on-line access was donated by the United States National Nuclear Data Center at Brookhaven, New York. The databases are maintained and updated by networks of nuclear data centres.

In addition to the new on-line service, copies of the available nuclear and atomic databases, or selective retrievals from them, continue to be provided on magnetic tapes or diskettes, upon request. Available data and services are advertised to data users by means of an *Index of Data Libraries* (document IAEA-NDS-7) and by the *Nuclear Data Newsletter*, of which more than 4000 copies are distributed to nuclear scientists in Member States.

During 1992, the Agency fulfilled more than 700 requests from 69 Member States for experimental and evaluated nuclear data, related data processing computer codes and nuclear data publications.

Establishment of international reference libraries for use in fusion reactor technology

A special purpose nuclear data library, FENDL, was developed for fusion applications. Not only will this work, during which the data processing code system NJOY was tested and improved, serve fusion design groups (including ITER), but the same validated codes and data files will also serve other applications.

Recommended atomic databases were established for neutral hydrogen beam plasma heating and diagnostic systems, light ion reflection from plasma facing fusion reactor materials and physical sputtering of first wall reactor materials under light ion impact.

Progress was made in the establishment of other databases in such areas as neutral helium based fusion plasma diagnostics, beryllium and boron plasma impurities, plasma radiative losses by carbon and oxygen impurities, plasma interaction induced erosion of fusion reactor materials and thermomechanical properties of plasma facing materials.

Development of databases for non-energy applications

Contributions from participants at a CRP on atomic and molecular data for radiotherapy were used in the preparation of a handbook on the subject. The handbook will be published in 1993.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Measurement and analysis of double differential neutron emission cross-sections	1992	7
1989	Atomic and molecular data for fusion edge plasmas	1993	12
1989	Atomic and molecular data for radiotherapy	1993	14
1989	Activation cross-sections for the generation of long lived radionuclides	1994	10
1991	Plasma interaction induced erosion of fusion reactor materials	1994	10
1991	Compilation and evaluation of fission product yield nuclear data	1994	7
1991	Atomic data for medium and high Z impurities in fusion plasmas	1995	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Improvement of measurements, theoretical computations and evaluations of neutron induced helium production cross-sections	3	9

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on applications of nuclear data and measurement techniques in nuclear reactor and personal neutron dosimetry	Russia	18	4 weeks
Workshop on computation and analysis of nuclear data relevant to nuclear energy and safety	ICTP, Trieste	42	5 weeks

Publications

Series and No.	Title
Annual publication	CINDA 92: Supplement to CINDA 91
Newsletter	Nuclear data newsletter, Nos 16 and 17
INDC(NDS)-253	Helium beam database for alpha particle diagnostics of fusion plasmas
INDC(NDS)-254	Atomic database for beryllium and boron
INDC(NDS)-255	Radiative losses and electron cooling rates for carbon and oxygen plasma impurities
INDC(NDS)-256	Status of thorium cycle nuclear data evaluations
INDC(NDS)-257	Atomic and molecular data for fusion plasma impurities
INDC(NDS)-260	FENDL-2 and associated benchmark calculations
INDC(NDS)-261	Compilation and evaluation of fission yield nuclear data
INDC(NDS)-262	Meeting of the network of the nuclear reaction data centres
INDC(NDS)-264	Nuclear data for neutron multiplication in fusion reactor first wall and blanket materials
INDC(NDS)-265	Total neutron cross-section of ^{238}U with neutrons of 55 keV and 144 keV
INDC(CCP)-333	Neutron leakage spectra from an iron sphere with a 14 MeV neutron source

Nuclear instrumentation

Maintenance of nuclear instrumentation

The maintenance of nuclear instruments was the topic of several technical co-operation projects. Specifically, two regional co-operation projects on nuclear instrumentation in Latin America and in Asia were largely devoted to servicing and maintenance problems. A spare parts provision service under these projects continued in 1992.

Nuclear spectroscopy

The development of computer software for nuclear applications continued, with one of the activities being the improvement of the codes for gamma and X ray analysis. A new module with a specific gamma library was developed for concentration calculations for fast neutron activation analysis. It was tested and added to the GANAAS (gamma spectrum analysis and neutron activation analysis) code. A major update of SPEDAC, the transfer and reformatting of spectra program, was carried out.

Laboratory activities

The Instrumentation Unit of the Agency's Laboratory at Seibersdorf provided technical support in establishing and/or upgrading infrastructures for the repair and maintenance of nuclear instruments in developing Member States, particularly in the Africa region. Expert missions were conducted and there was rapid provision of relevant equipment, spare parts and service manuals.

To support training in the maintenance of XRF equipment, a manual on the installation, maintenance, troubleshooting and repair of an X ray generator for XRF analysis was prepared. The Laboratory also contributed to the preparation of a report in the IAEA-TECDOC series on the protection of nuclear instruments; this report is planned for publication in 1993. The document covers the major classes and sources of interference in power supplies, and also deals with power protection and air-conditioning for instruments.

An Advisory Group meeting on nuclear spectroscopy software evaluated the Quantitative X Ray Analysis System (QXAS) software package distributed by the Agency to about 60 X ray analytical laboratories in developing Member States. Recommendations were formulated for further development of X ray spectra evaluation and quantitative procedures included in the software package.

The major components of an XRF set-up, including capillary optics, sample holder and optical microscope, were acquired by the Laboratory and were installed and tested. The microfluorescence system will be used to perform quantitative trace element analysis of different environmental materials, with a spatial resolution of the order of a few micrometres.

The Instrumentation Unit was also involved in circuit design and the construction of special instruments which are not available commercially. For example, a temperature control unit was constructed for the irradiation compartment of the Agency's gamma cells. In addition, UNOLAB modules, such as a double delay line amplifier, HV power supply and spectroscopy RC shaping amplifier were designed and constructed. The modified complete UNOLAB single channel spectroscopy system will be distributed in kit form to some developing Member States.

Two group fellowship training courses in nuclear spectroscopy instrumentation maintenance (54 person-months) and in XRF analysis (12 person-months) were organized at the Laboratory. In addition, a number of individual on the job training courses in the relevant fields (22 person-months) were hosted.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on interfacing in nuclear experiments	Indonesia	19	9 weeks
Regional course on service and maintenance of personal computers and related instruments	Uruguay	15	2 weeks
Regional workshop on nuclear instrumentation in industry	Chile	12	1 week
Seminar on the repair and maintenance of nuclear instruments	Kenya	21	1 week

Theoretical physics

Fields of research and training

The main fields of research and training for research at the International Centre for Theoretical Physics in 1992 were: fundamental physics (high energy, astrophysics, cosmology and particle physics); condensed matter physics (condensed matter physics and related atomic and molecular physics, materials science and engineering, computational condensed matter, surfaces and interfaces, liquids and statistical mechanics); mathematics (applicable mathematics, systems analysis, mathematical ecology, mathematics in development, algebraic geometry, differential equations, analysis and mathematical physics); physics and energy (plasma physics and nuclear physics); physics and the environment (geophysics, oceanography, seismology, climatology and meteorology, physics of the atmosphere, and remote sensing); physics of the living state (neurophysics, medical physics, biophysics); applied physics and high technology (physics in industry, microprocessors, communications, instrumentation, synchrotron radiation, VLSI design, optical fibres, lasers and computational physics).

Approximately 4000 scientists took part in the activities of the Centre and in the programme for training at Italian laboratories, for a total of more than 4000 person-months. Of this total, 56.76% came from developing countries, accounting for 80% of the total person-months. Associate Members from developing countries numbered 441, and there were 376 federated institutes in developing countries.

Funding

The financial agreement with the Italian Government has been renewed up to 31 December 1994 by the Italian Parliament. During 1992, the Centre received the balance of the 1991 Italian contribution. The implementation of the 1992 programme was made possible through the financial contribution from the Italian Government of $18 691 589. The contributions of the Agency and UNESCO amounted to $1 218 000 and $339 700, respectively.

The Centre also acknowledges with gratitude contributions from SAREC (Sweden) $568 599; UNIDO (regular) $250 000; Japan, $39 120; Switzerland, $10 418; Brazil, $16 000; France (CNES), $5556; the Italian National Institute for Nuclear Physics (INFN) $39 378; Italy (SIRS/ASI) $140 288; Italy (CNR) $200 803; Denmark (NORDITA) $14 381; Norway (FNI) $15 337; Spain (CICT) $15 000; the United Kingdom (Royal Society) $33 972; and the United Nations University (UNU) $9981.

Adriatico Research Conferences

In 1992, the Adriatico Research Conference series included short meetings on: polarization dynamics, clusters and fullerenes, wrinkling of surfaces, synergetics in condensed matter and hydrogen atoms. Seventy-nine scientists from developing countries, out of a total of 305, took part.

Training at Italian laboratories

More than one hundred scientists from developing countries carried out research at Italian academic and industrial laboratories under a programme which started in 1982 with the financial support of the Italian Direzione Generale per la Cooperazione allo Sviluppo (Italian Ministry of Foreign Affairs, Rome).

External activities

In the fields of physics and pure and applied mathematics, the Centre sponsored 28 activities, courses, workshops and symposia in 16 countries. Thirteen Affiliated Centres were established in 13 countries and 4 networks were created involving 23 countries, plus 5 visiting scholars. These programmes were financed by the Direzione Generale per la Cooperazione allo Sviluppo of the Italian Ministry of Foreign Affairs.

Meetings hosted by the Centre

The Centre hosted ten meetings. The major organizing institutions were the International Centre for Genetic Engineering and Biotechnology; UNESCO; Third World Academy of Sciences; Italian National Institute for Nuclear Physics; International School for Advanced Studies; and the Politecnico of Milan.

Other meetings

A three day conference on the essential role of science in technological progress and economic development was held in March in Trieste, with a panel of 30 scientists, 15 economists and 10 eminent professionals from Third World countries. The aims of the conference were to narrow the gap between science and economics and evolve a strategy to be adopted for the future.

Books and equipment donation programme

During the period October 1991–August 1992, the Centre distributed 17 286 journals, 16 045 proceedings, 1594 books and 1644 miscellaneous publications to some 1500 institutions in 100 developing countries. In addition to the donations directly distributed by the Centre, a large number of donations of complete sets of back issues of journals were shipped directly by the donors to institutions in developing countries.

Awards

The 1992 Dirac Medals of the ICTP were awarded to N.N. Bogolubov (posthumously), formerly of the Joint Institute for Nuclear Research, Moscow, and to Y.G. Sinai, from the Landau Institute for Theoretical Physics, Moscow, Russia. N.N. Bogolubov's award was in recognition of his many fundamental contributions in physics and mathematics. In statistical physics, his treatment of Bose–Einstein condensation in a non-ideal gas was a seminal work which laid the basis for a microscopic theory of superfluidity in helium II. Y.G. Sinai received the Dirac Medal for his outstanding contribution to theoretical physics and mathematics through the development of ergodic theory and its applications to dynamical systems, in particular billiards, phase transitions, quantum chaos and hydrodynamics. Also cited was his work on the spectral analysis of Schrödinger operators and applications of renormalization group theory.

The 1992 ICTP Prize in honour of V.F. Weisskopf was awarded to Élcio Abdalla, from the Universidade de São Paulo, Brazil, for his two dimensional quantum field theory.

Preprints and internal reports

In 1992, approximately 500 preprints and internal reports were issued.

Fields of research and training

Fundamental physics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in fundamental physics and astrophysics	124	63	1 year
Diploma course in high energy physics	20	14	9 months
Spring school on string theory and quantum gravity and workshop on string theory	111	30	2 weeks
Trieste workshop on the search for new elementary particle physics	36	9	3 days
Summer school on high energy physics	241	147	6 weeks

Condensed matter, atomic and molecular physics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in condensed matter physics	89	63	1 year
Diploma course in condensed matter physics	27	15	9 months
Topical workshop on coherent atom-radiation interactions	71	43	2 weeks
Spring college and experimental workshop on superconductivity and high temperature superconductor advanced activities	129	84	7 weeks
Seventh Trieste semiconductor symposium	140	9	1 week
Miniworkshop on strongly correlated electron systems	65	24	3 weeks
Research workshop on condensed matter physics and 25th anniversary symposium on condensed matter physics	282	194	6 weeks
Miniworkshop on non-linearity	48	18	2 weeks
Miniworkshop on methods of electronic structure calculations	69	41	2 weeks
Course on low dimensional quantum field theory for condensed matter physics	105	44	2 months

Mathematics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in mathematics	94	71	1 year
School on dynamical systems	93	54	2 weeks
Workshop on dynamical systems	105	63	2 weeks
Advanced workshop on algebraic geometry	120	64	2 weeks

Physics and energy

Course name	Total No. of participants	Participants from developing countries	Duration
Research in plasma physics	9	6	1 year
Workshop on computation and analysis of nuclear data relevant to nuclear energy and safety	64	39	1 week
Workshops and conference on global change and environmental considerations for energy systems development	70	41	3 weeks

Physics and the environment

Course name	Total No. of participants	Participants from developing countries	Duration
ICS-ICTP-WMO international workshop on Mediterranean cyclone studies	35	16	4 weeks
Workshop on tropical climate variability and regional impacts	40	25	1 week

Physics of the living state

Course name	Total No. of participants	Participants from developing countries	Duration
College on neurophysics–object recognition by man and machine	67	39	3 weeks
College on medical physics: Imaging and radiation protection	66	50	3 weeks

Applied physics and high technology

Course name	Total No. of participants	Participants from developing countries	Duration
Microprocessor laboratory	8	5	1 year
High temperature superconductivity experimental laboratory	12	9	1 year
Laboratory for lasers and optical fibres	35	11	1 year
Third training college on physics and technology of lasers and optical fibres	107	70	3 weeks
Computer network project	84	58	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-676	International Centre for Theoretical Physics: Scientific activities in 1991

Utilization of research reactors and particle accelerators

Optimization of research reactor operation, utilization and management

Support continued for activities related to the improved utilization and safe operation of research facilities. Issues examined in particular were the conversion of reactors for operation with low enrichment uranium fuels, better utilization of reactors for fundamental and applied research programmes, and technical and safety issues arising from the continued operation of old research reactors. Guidance and advice were given for establishing new research reactors and for upgrading, refurbishing and improving existing facilities.

The development of new codes and adaptation of mainframe computer codes for personal computers were supported through research contracts. The results will be useful in analysing the performance of reactors and in the assessment of safety margins for various operating conditions.

The Research Reactor Database was updated. Work on adaptation of this database to personal computers progressed.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Application of personal computers to enhance the operation and management of research reactors	1995	9

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course (RCA) on measurement of the basic parameters of research reactors	Indonesia	13	3 weeks
Regional course (RCA) on safety documentation of research reactors	Bangladesh	14	2 weeks
Regional workshop (RCA) on neutron transmutation doping technology	China	13	1 week

Publications

Series and No.	Title
IAEA-TECDOC-633	Determination of research reactor fuel burnup
IAEA-TECDOC-643	Research reactor core conversion guidebook: Summary Analysis Analytical verification Fuels Operations

Chemistry

Production of new radiopharmaceuticals of $^{99}Tc^m$ and $^{99}Tc^m$ generators from low specific activity ^{99}Mo

Under a CRP on the evaluation of bulk reagents for the production of $^{99}Tc^m$ radiopharmaceuticals and kits, progress was made in the synthesis, analysis, evaluation and kit formulation of these reagents. From the available protocols, published procedures or procedures available from other participants in this CRP, it was possible to synthesize the ligands d,l-HMPAO, MAG_3, MIBI, ECD and EC. Certain reaction steps were optimized and observations were made concerning the selection of raw materials, solvents and reaction conditions to best suit the available laboratory facilities. Improved methods were reported concerning the purification of d,l-HMPAO and the isolation of MIBI chelates.

Indigenous production of reagents for assays of thyroid related hormones

Under a CRP on antibodies immobilized on magnetic particles for the radioimmunoassay (RIA) and immunoradiometric (IRMA) assay of hormones, magnetic particles with excellent characteristics for antibody immobilization were produced in three user centres in Hungary and China. Anti-TSH monoclonals of high quality were produced in Thailand. These reagents have been used in the development of low cost, analytically reliable RIA/IRMA of thyroid related hormones.

Analytical quality control

New methods for selective separation and preconcentration were developed for analytically reliable assays of trace elements of environmental interest under another CRP that was recently concluded. The theme of this CRP was the use of radiotracers in the development of new separation techniques for trace element analysis by nuclear methods, with special emphasis on environmental research.

Laboratory activities

The Chemistry Unit of the Agency's Laboratory at Seibersdorf organized five intercomparisons using U ore (phosphate), soil, grass, spinach and cabbage, two of which (soil and grass) were collected near the Chernobyl nuclear power station. An intercomparison on the determination of trace elements in spinach was organized in co-operation with the United States National Institute of Standards and Technology, which donated the material. The cabbage was produced by the Chemistry and Agrochemicals Units of the Agency's Laboratory to meet the increasing needs for natural matrix reference materials that have been characterized for a variety of organic contaminants, including agrochemical residues. The other three materials were distributed to determine the uranium, thorium, radionuclide and trace element content. In addition, 24 intercomparison runs were organized with the assistance of the Analytical Quality Control Services (AQCS) programme.

In order to assist in quality assurance in studies of the long term consequences of nuclear accidents, the recommendations from a consultants meeting on analytical quality control services, which was held in Vienna, were implemented by organizing an additional intercomparison run for the determination of ^{129}I in Soil IAEA-375. To include so-called difficult elements, such as Pu, Np and Am, AQCS, in co-operation with the Radium Institute, St. Petersburg, Russia, collected and prepared two different soil materials for the determination of different types of radionuclides, and formulated plans to organize future intercomparisons.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Nuclear analytical techniques for trace element analysis in agricultural products and food	1992	11
1989	Radiotracers in the development of new separation techniques for trace element analysis by nuclear methods, with special emphasis on environmental research	1992	14
1990	Labelling, quality control and clinical evaluation of monoclonal antibodies for scintigraphy	1993	13
1990	Evaluation of bulk reagents for production of $^{99}Tc^{m}$ radiopharmaceutical kits	1993	10
1991	Antibodies immobilized on magnetic particles for radioimmunoassay and immunoradiometric assay of hormones	1994	10
1991	Alternative technologies for $^{99}Tc^{m}$ generators based on low temperature sublimation and gel elution	1994	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Optimization of the production and quality control of radiotherapeutic radionuclides and radiopharmaceuticals	3	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on preparation and quality control of radiopharmaceuticals	China	17	3 weeks
Regional workshop on applications of flow injection analysis for the analysis of environmental and geological samples	Brazil	12	2 weeks
Regional workshop on collection strategies and preparation of samples in environmental problems	Chile	13	2 weeks
Regional workshop on radiopharmaceutical kit preparation	Colombia	10	2 weeks
Regional workshop on the synthesis of radiopharmaceuticals	Argentina	10	3 weeks
Workshop on quality control in hospital radiopharmacy	United Arab Emirates	19	2 weeks

Publications

Series and No.	Title
Chemical Thermodynamics Series	The chemical thermodynamics of actinide elements and compounds: Part 12. The actinide aqueous inorganic complexes
IAEA-TECDOC-649	Preparation of kits for $^{99}Tc^{m}$ radiopharmaceuticals

RADIATION PROTECTION

Programme overview

The major focus of activities under the Radiation Protection programme in 1992 was the ongoing development of new international Basic Safety Standards for protection against ionizing radiation and for the safety of radiation sources. The 1990 Recommendations of the ICRP are to be taken into account in the new Standards, which will replace the 1982 edition of the Basic Safety Standards. The new Standards, jointly sponsored by the Agency, FAO, ILO, OECD/NEA, PAHO and WHO, will give guidance on the features of regulatory regimes for radiation protection, the control to be applied when introducing and following any practice which might increase the potential for radiation exposure, and the criteria for intervening in order to reduce existing exposures.

Support continued to be given to the United Nations International Co-operation Project for Chernobyl. A joint project with FAO on the use of caesium binders for reducing radiocaesium contamination of the milk and meat of grazing animals has seen the completion of laboratory studies and limited field tests in the three areas affected by contamination from the Chernobyl accident.

In the area of safe transport of radioactive material, work is in progress towards the next edition of the Agency's Transport Regulations, due in 1996. Particular emphasis was placed in 1992 on achieving consistency with the revised edition of the Basic Safety Standards. Attention was also focused on the shipment of high toxicity materials, such as plutonium.

The Emergency Response Unit was maintained at a high state of readiness; a duty officer system was continuously in operation whereby senior technical staff members were constantly available to determine the significance of accident reports and to initiate appropriate actions.

Radiation Protection Advisory Team (RAPAT) reviews were conducted in Albania, Poland and the United Arab Emirates. A survey indicated that RAPAT recommendations were being followed closely and were helping to improve radiation protection in many developing countries.

Budget cuts led to programmatic reductions, mainly in research activities. One major meeting and four Technical Committee and Advisory Group meetings had to be deferred until 1993.

Basic radiation safety policy

Basic safety principles, criteria and standards for radiation protection

Work continued on the development of new standards for protection against ionizing radiation and the safety of radiation sources. These will reflect the 1990 recommendations of the ICRP and will replace the 1982 edition of the Basic Safety Standards for Radiation Protection. The revision is being carried out by a joint secretariat representing the Agency, FAO, ILO, OECD/NEA, PAHO and WHO. Among the features of the new Standards are the following:

- Requirements for the safety of radiation sources are being included; these requirements are intended to restrict the probability of potential exposures which could occur following unplanned events such as accidents, errors or equipment failures;
- Requirements for controlling occupational exposure to naturally occurring sources of radiation are being extended beyond uranium mining to include other mines and workplaces where high levels of radon and its radioactive decay products occur;
- Requirements are being included for 'intervention' to reduce exposures from sources of radiation that exist as a result of earlier practices or accidents to avoid doses that would otherwise be received after current accidents and to reduce undesirably high levels of naturally occurring radiation in homes.

A preliminary draft of the new Standards was sent to Member States for comment in June. The comments received were incorporated into a second draft which was reviewed at a Technical Committee meeting in December.

General activities

Pursuant to Resolution GC(XXXV)RES/552, a comprehensive proposal for education and training in both radiation protection and nuclear safety was presented for consideration at the regular session of the General Conference. The proposal was approved (Resolution GC(XXXVI)RES/584) and the Agency was requested to implement it.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on planning, organization and implementation of radiation protection at a national level	USA	32	3 weeks
Regional course on regulatory practices for radiation safety	United Arab Emirates	9	2 weeks

Occupational radiation protection

Occupational radiation protection in design and operations

Documents produced as part of the Agency's programme on the control and safe use of radiation sources feature extensive use of graphics. This approach will be used in the preparation of a new series of documents on occupational radiation protection. The first will be a module on workplace monitoring for radiation and contamination. Up to sixteen documents providing practical guidance on the principles and practices of occupational radiation protection are planned.

Individual monitoring for external radiation

Following publication by the ICRU of guidance on the use of a new set of operational quantities for the external monitoring of personnel, the Agency conducted a CRP to evaluate the impact of these recommendations on dosimetry programmes in Member States. It was concluded in this CRP, which was completed in February, that more work was needed to ensure the proper interpretation of dosimetry results.

Individual monitoring for internal contamination

The provision of guidance on accurate internal dosimetry for occupationally exposed workers and for members of the public received considerable attention. Two Safety Series reports were drafted and two more are under development. A CRP on the anatomical, physiological and metabolic characteristics for a Reference Asian Man has resulted in the compilation of a large quantity of data.

Overexposure assessment and handling

A Safety Guide on the assessment and treatment of external and internal accidental radionuclide contamination was drafted and should be finalized in 1993.

A draft of a technical document on schemes for the prognosis and treatment of radiation injuries was prepared.

The development of a register of radiological accidents — Radiation Accident Database (RADAC) — was initiated and the first version of a questionnaire was drafted. The purpose of this database is to store information on radiological accidents which involve significant exposure to individuals or significant economic loss. The data will include the nature of the accident, its causes and consequences. Severe radiation accidents in Israel in 1990 and in Belarus in 1991 were investigated and reports were drafted incorporating the lessons to be learned.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Compilation of anatomical, physiological and metabolic characteristics for a Reference Asian Man	1993	11
1988	Dose per unit intake factors for members of the public	1993	11
1988	Intercomparison for individual monitoring	1992	24
1990	Assessing the absorbed dose in natural materials	1993	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on dosimetric assessment of internal contamination	Australia	16	3 weeks

Radiation protection of the public and the environment

Limiting radioactive releases

Considerable work was carried out to revise concepts for the protection of the public and the environment and to develop numerical guidance to be included in the revised Basic Safety Standards. In particular, a publication in the IAEA-TECDOC Series was issued on source related dose constraints for limiting routine releases; another technical document was drafted on intervention levels. This document will embody international harmonization of intervention levels for accidents.

Monitoring of routine discharges

Work continued on two documents on radionuclide monitoring. The first relates to monitoring a release at its source and the second to monitoring concentrations in the environment during normal operations.

Post-accident environmental monitoring

Work on the Validation of Model Predictions (VAMP) project continued, with a technical document being drafted on the shielding effects of buildings.

As a follow-up to the Atmospheric Transport Model Evaluation Study (ATMES) project, the Agency is participating in the planning for the European Tracer Experiment (ETEX). The aim of this project is to release an inert tracer in April 1994 and compare the dispersion of gas predicted by models run in real time with measurements made by participating laboratories.

A report on agricultural countermeasures following a major nuclear accident was prepared jointly with FAO.

Support was given to the implementation of the United Nations International Co-operation Project for Chernobyl. In a joint project with FAO on the use of caesium binders for reducing radiocaesium contamination in the milk and meat of grazing animals, laboratory studies and limited field trials were completed in the three areas affected by the Chernobyl accident.

A scientific research team from Japan concluded a research project agreement for studies within the framework of the Chernobyl Centre for International Research (CHECIR) and initiated field studies on decontamination. This project, in which foreign experts will closely co-operate with scientists from local institutions, represents the second major research project within this framework.

Assessment and control of radon exposures

A CRP on radon exposures in the human environment is continuing jointly with the CEC. Since 1992, extensive financial and technical support for this project has been provided by the United States Environmental Protection Agency.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Radon in the human environment	1994	55

Training courses and seminars held

Course name	Location	No. of participants	Duration
Measurement of environmental samples	Argentina	16	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-664	Establishment of source related dose constraints for members of the public: Interim report for comment

Safe transport of radioactive materials

The Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM) convened to make recommendations on the priority to be assigned to objectives within this subprogramme up to 1996.

Maintenance and implementation of the Agency's Transport Regulations

Activities seeking to review, revise and update the Agency's Regulations for the Safe Transport of Radioactive Material (Safety Series No. 6) continued. A meeting was held in Vienna to establish a programme of work to incorporate the latest recommendations of the ICRP into the Transport Regulations. This will ensure that the comprehensively revised 1996 edition of the Regulations will be consistent with the new edition of the Agency's Basic Safety Standards.

In response to growing interest in the international transport of high toxicity materials in large quantities, a joint IAEA/IMO Working Group was established and held its first meeting in London. This group will collaborate on matters relating to the safety of radioactive material transported by sea.

At an Advisory Group meeting in Vienna, the drafts were discussed of two Safety Series documents that provide guidance on compliance assurance for the benefit of competent authorities and on quality assurance for the management of transport operations.

Work on improving the Agency's training material for safe transport neared completion with the collection of visual aids and the preparation of an updated video film.

The PACKTRAM database supports the annual publication of a report on valid package approval certificates. Member State participation in PACKTRAM was increased. Data processing for REDTRAM, the database on research and development, will be undertaken by INIS in connection with its Research-in-Progress database. An automated data input programme was developed for EVTRAM (accidents and incidents) and data collection was pursued. Preparation of a report on the EVTRAM, SHIPTRAM (shipments of radioactive material in the nuclear fuel cycle) and EXTRAM (exposures during transport) databases had to be deferred owing to insufficient data.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Development of probabilistic safety assessment techniques related to the safe transport of radioactive materials	1993	12
1991	Assessment of safety of UF_6 packages in fires	1996	6

Publications

Series and No.	Title
IAEA-TECDOC-662	Directory of national competent authorities' approval certificates for package design, special form material and shipment of radioactive material: 1992 edition
IAEA-NCAL-23	National competent authorities responsible for approvals and authorizations in respect of the transport of radioactive material: List No. 23
IAEA-NCAL-24	National competent authorities responsible for approvals and authorizations in respect of the transport of radioactive material: List No. 24

Emergency planning and preparedness

Guidelines for emergency planning and preparedness

A document providing guidance on the international exchange of information and data following a major nuclear accident or radiological emergency was published. It was designed primarily for those organizations operating national emergency response programmes which have responsibility for implementing conventions and for protecting and informing the public.

There were two meetings of the Interagency Committee for the Response to Nuclear Accidents. The Committee adopted a document on radiological emergency response co-ordination, which provides the principles and details of co-ordination between United Nations organizations in response to a nuclear accident or radiological emergency.

Emergency assistance services

The Agency's Emergency Response System (ERS) was maintained in a fully operational state 24 hours a day. The duty officer system was expanded during 1992 so that coverage is now shared between 30 Agency staff members.

Work continued on improving the capabilities of the Emergency Response Unit and the overall effectiveness of the ERS. The major activities included the following:

- A second comprehensive exercise, which was conducted in January to test the ERS and the procedures developed to support the Conventions on Early Notification of a Nuclear Accident and Assistance in the Case of a Nuclear Accident or Radiological Emergency. The emergency exercise involved about fifty Agency staff members as players, controllers and evaluators, plus five Member States, their Permanent Missions to the Agency and six international organizations. A report on the lessons learned was produced and distributed.
- The implementation procedures for the ERS were reviewed, primarily on the basis of the lessons learned from the ERS exercise plus operational experience. The Handbook of Emergency Response Procedures was accordingly modified and reissued.
- An incident at Unit 3 of the Sosnovyi Bor nuclear power plant near St. Petersburg, Russia, in March prompted the Agency to utilize aspects of the ERS to collect details about the incident, assess the available data and provide this information and the assessments to the media, Member States and other international organizations.
- Arrangements were made during the year to receive facsimile messages sent to the Agency in accordance with the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on Early Notification of a Nuclear Accident. All methods of communication which a Member State may use to make an initial notification or request for assistance are now covered by the Security Control Centre during non-working hours.

The Agency was also represented in an OECD/NEA expert group which is preparing for the first international exercise for the response to a nuclear accident. In addition, the final draft of a Safety Series document on emergency planning and preparedness for the re-entry of a nuclear powered satellite was completed.

Publications

Series and No.	Title
Special publication	Guidance on international exchange of information and data following a major nuclear accident or radiological emergency

Control and safe use of radiation sources

Design, control and safe use of radiation sources

A video film was prepared on the safety of industrial irradiators. A report on the radiological accident in Israel is in preparation.

Work is continuing on a CRP on radiation doses in diagnostic radiology and methods for reduction. A pilot programme to be carried out in ten Member States will be finalized in 1993.

Information on the control and safe use of radiation sources

A post-accident review meeting took place to investigate the causes and consequences of a fatal radiation accident in Nesvish, Belarus, in October 1991. In this accident, an operator of an irradiation unit received an estimated whole body dose of 12 Gy. A report is in preparation.

Probabilistic safety assessment techniques to improve the safety of radiation sources

A computerized model for the probabilistic safety assessment (PSA) of transport accidents involving radioactive materials is being elaborated. A status report on PSA techniques for nuclear facilities other than reactors was also expanded to include consideration of radiation sources used in industrial, medical and other applications.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Radiation doses in diagnostic radiology and methods for reduction	1993	16

Training courses and seminars held

Course name	Location	No. of participants	Duration
Control and safe use of radiation sources	Kenya	27	3 weeks
Radiation protection in medical practices	Morocco	30	3 weeks
Safe operation of industrial radiation facilities: Regulatory responsibilities	Ecuador	22	2 weeks
	Czechoslovakia	11	2 weeks

Publications

Series and No.	Title
Safety Series No. 107	Radiation safety of gamma and electron irradiation facilities
IAEA-PRSM-1	Practical radiation safety manual: Gamma radiography
IAEA-PRSM-2	Practical radiation safety manual: Shielded enclosures
IAEA-PRSM-3	Practical radiation safety manual: Nuclear gauges
IAEA-PRSM-4	Practical radiation safety manual: High energy teletherapy
IAEA-PRSM-5	Practical radiation safety manual: Brachytherapy
IAEA-PRSM-6	Practical radiation safety manual: Therapeutic uses of iodine-131
IAEA-TECDOC-663	Efficiency in development and implementation of safety regulations for the use of ionizing radiation

Radiation safety services

Radiation Protection Advisory Team (RAPAT) services

Three RAPAT missions were conducted in 1992 in Albania, Poland and the United Arab Emirates. A survey indicated that RAPAT recommendations were being followed closely and were leading to a considerably higher level of radiation protection in many developing countries.

A project to provide radiation protection services to 16 African Member States continued. An appraisal of the status of radiation protection in the 16 countries showed that 11 Member States had enforced radiation protection legislation and 4 had at least an advanced draft ready to be promulgated. Fourteen of the 16 African Member States now have a well defined national competent authority and all 16 Member States have radiation protection services at various stages of development.

Laboratory services

The Radiation Protection Laboratory continued to routinely monitor more than 400 Agency staff categorized as radiation workers (external dose exposure and internal contamination monitoring). There were no cases of internal or external overexposure. As in the previous year, all individual doses were maintained far below the annual dose limits. A new TLD reader was procured which offered better dose evaluation capabilities. Combined with the new software developed by Agency staff, this will provide an up to date dosimetry service.

Individual monitoring services continued to be provided to Member States and co-operation with WHO also continued. Approximately 9000 monitoring badges were distributed and 1000 finger dosimeters were sent to Member States.

Data from the whole body counter at the Agency's Laboratory at Seibersdorf revealed that general levels of individual internal body burdens of ^{137}Cs have now declined to values observed before the Chernobyl accident. An intercomparison exercise was organized among 23 laboratories on ^{40}K, ^{131}I and ^{125}I measurements.

A new laboratory for the chemical radioanalysis of urine samples is being completed and will be operational in early 1993.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on planning, organization and implementation of radiation protection at a national level	USA	32	3 weeks
National workshop on radiation protection in medicine	Zimbabwe	25	2 weeks
National workshops on radiation protection in diagnostic radiology and radiotherapy for (1) specialists and (2) nurses	Viet Nam	(1) 32 (2) 16	2 weeks 1 day
Regional course on regulatory practices for radiation safety	United Arab Emirates	32	2 weeks
Regional workshop on the development of training techniques and methods of instruction in radiation protection	Australia	14	2 weeks
Regional workshop on intercomparison for personal dosimeters	Japan	13	1 week
Workshop on legislation for radiation protection	United Arab Emirates	22	1 week
Seminar on health effects of ionizing radiation for medical doctors	Poland	150	3 days

SAFETY OF NUCLEAR INSTALLATIONS

Programme overview

The emphasis of work in 1992 under the programme on the safety of nuclear installations continued to shift from establishing standards of safety to providing for the application of standards. Another main area of focus was the safety of nuclear power plants in eastern Europe and States of the former USSR.

At its February 1992 session, the Board of Governors authorized the Director General to set up an open-ended working group of legal and technical experts with the task of carrying out preparations for a nuclear safety convention. At a meeting in October, the expert group based its discussions on a draft text of a nuclear safety convention. It was concluded that further work was needed to define the nature of the specific safety obligations and the method of implementing the convention.

A new Safety Series report, 75-INSAG-7, was issued by the International Nuclear Safety Advisory Group to update 75-INSAG-1, a summary report on the Post-Accident Review Meeting on the Chernobyl Accident. Using new information available since 1986, the report discusses faults in the design of the reactor's control rods and safety systems, and deficiencies in the regulation and management of safety.

Operational Safety Review Team (OSART) and Assessment of Safety Significant Event Team (ASSET) missions continued to be effective in assisting Member States in the enhancement of safe plant operation. This was confirmed by the results of OSART Follow-Up Visits.

In 1992, a possible new safety service was tested. The Assessment of Safety Culture in Organizations Teams (ASCOTs) would review the effectiveness of safety culture on the basis of principles and recommendations contained in Safety Series No. 75-INSAG-4. For this purpose, ASCOT guidelines were also under development.

The International Nuclear Event Scale (INES) is now used in many countries to rate nuclear incidents. A related information system was made operational through which INES national officers in 50 Member States are provided with timely information. In 1992, information on 72 nuclear events was communicated through the system which is continuously operational. A test period was started for the use of the scale for events in facilities other than nuclear power plants.

The Agency continued to implement an extrabudgetary programme of assistance to eastern Europe and States of the former USSR. In the area of nuclear plant safety assessment, Agency efforts helped to achieve a consensus on the technical safety issues for the first generation WWER-440 Model 230 reactors. Phase 2 of this project has the objective of helping countries ensure that the assistance they receive conforms with the project's Phase 1 findings. The Agency is also initiating a project on RBMK reactors. This project will review the technical basis for safety improvements proposed by Russian scientists and also seek to establish a consensus on the required improvements. At the request of several countries, a programme dealing with the more modern WWER-1000 plants has also been set up.

A budget shortfall resulted in a reduced level of activities, mainly in the field of research. A number of meetings had to be deferred until 1993.

Basic nuclear safety principles and criteria

Basic nuclear safety principles and criteria

The Director General was requested by Resolution GC(XXXV)/RES/553 to prepare, for consideration by the Board of Governors in February 1992, an outline of the possible elements of a nuclear safety convention, taking into account the activities and roles of relevant international and intergovernmental bodies and drawing on the advice of standing groups such as INSAG, NUSSAG and INWAC, and also on expertise made available by Member States and competent international organizations. At its February session, the Board of Governors authorized the Director General to set up a working group of legal and technical experts with the task of carrying out preparations for a nuclear safety convention. At the regular session of the General Conference, Resolution GC(XXXVI)/RES/582 urged the expert group to continue its work in the context of the "vital necessity of a continuing effort to raise the general level of nuclear safety worldwide". The expert group, which met in October, based its discussions on a revised working paper containing a draft text of a nuclear safety convention. There was agreement that the objective was to achieve an "incentive" convention at an early date to which a large number of States would adhere. It was agreed that civil nuclear power plants would be covered by the convention, though the view was expressed that the scope of the convention should be broader. It was recognized that a final decision on the scope of the convention had to await further discussion.

The International Nuclear Safety Advisory Group (INSAG) continued to advise the Director General in the field of nuclear safety and to consider safety issues important to the nuclear community. Concern over the misapplication of PSA and its methods and the misinterpretation of its results led INSAG to prepare a report (Safety Series No. 75-INSAG-6) on PSA's merits and limitations.

A report updating an earlier publication on the Chernobyl accident (Safety Series No. 75-INSAG-1) was published in December. In the new report (Safety Series No. 75-INSAG-7), the earlier conclusions reached about the causes of the accident were reviewed. It was found that design factors played a greater role in the accident than was previously acknowledged. The report includes a number of conclusions and an appendix on safety measures already taken and to be taken to enhance the safety of RBMK reactors.

The first meeting of INSAG's third term was held in September. A number of safety issues were selected as items for future work, such as the safety of older reactors; approaches for upgrading nuclear power plants to recent standards; implementation of defence in depth for current and future reactors; and a consistent approach to potential exposures to radiation in all nuclear activities.

Nuclear power plant safety standards

The Agency's Nuclear Safety Standards Advisory Group (NUSSAG) reviewed and recommended for publication in the Safety Series a draft text on the safety of nuclear installations. Also reviewed was progress on a draft revised Safety Standard and on two draft revised Safety Guides, all of which deal with quality assurance at nuclear power plants. A draft document on regulatory inspection and enforcement and good practices for nuclear power plants was recommended for publication.

Technical and regulatory review services

International Regulatory Review Team (IRRT) visits are a relatively new service offered by the Agency. Only two missions have been conducted: one to Brazil in 1989 and the second to Romania in February 1992. The purpose of the IRRT programme is to provide advice and assistance to Member States to strengthen and enhance the effectiveness of their nuclear regulatory bodies, while recognizing the ultimate responsibility of each Member State for the safety of its nuclear installations. An IRRT team reviews national approaches to the regulation of nuclear safety on the basis of international consensus guidelines and good practices, as encapsulated by the Agency's Safety Series documents, in particular the NUSS publications, and on the experience of IRRT members.

Publications

Series and No.	Title
Proceedings Series	The safety of nuclear power: Strategy for the future
Safety Series No. 75-INSAG-5	The safety of nuclear power. A report by the International Nuclear Safety Advisory Group
Safety Series No. 75-INSAG-6	Probabilistic safety assessment
Safety Series No. 75-INSAG-7	The Chernobyl accident: Updating of INSAG-1

Safe siting and design of nuclear installations

Site characteristics and external hazards for nuclear installations

A draft report on the procedure for the treatment of external hazards in PSA was completed. The report is at present in the review process and should be published as a Safety Practices document.

Structural safety issues related specifically to the protection of nuclear power plants against external events were reviewed in a Technical Committee meeting in May. Two documents were considered, one on simplified methods for earthquake resistant design and another on verification of nuclear facilities, including those with a limited radioactive inventory.

Current issues relating to safety analysis of nuclear power plants

Several site/seismic safety reviews carried out in 1992 were follow-up activities of recommendations made in missions to sites in 1990 (Kozloduy in Bulgaria, Bohunice in Czechoslovakia, Muria in Indonesia and Chashma in Pakistan). New reviews involved one plant currently shut down (the Armenia nuclear power plant in Armenia) and one in operation (Krško in Slovenia).

A working document, to be used as the basis for a CRP on a benchmark study for seismic analysis and testing of WWER-type nuclear power plants, was prepared at a consultants meeting in April. A second preparatory meeting to define the scope and participation of each institute and the work plan was held in December.

Evaluation of advanced plant designs from the safety viewpoint

The main focus of activities in the area of advanced plant design evaluation was the implementation of Resolution GC(XXXV)/RES/553. At a consultants meeting in June, a background paper was prepared and a review was carried out of the INSAG reports on basic safety principles for nuclear power plants (Safety Series No. 75-INSAG-3) and the safety of nuclear power (75-INSAG-5) as they relate to safety principles for future nuclear power plants. Items for further investigation were identified at an Advisory Group meeting in June–July. This material contributed to Board of Governors reports on measures to strengthen international co-operation in matters relating to nuclear safety. A draft of a technical document on safety principles for future nuclear power plants and on the safety role of containment was prepared. A technical document on the safety aspects of future LWR designs was prepared on the basis of this work and submitted for publication.

Safety aspects of early failure detection systems

In the framework of the Agency's activities to review the safety of WWER-440 Model 230 nuclear power plants, the applicability of the leak before break (LBB) concept was identified as an issue of major safety significance. As a result, a comprehensive summary of technical information available in the field was undertaken and a report was prepared for publication in the IAEA-TECDOC Series. The report provides an overview of the basic LBB concept, reviews the regulatory approach and the status of application of this concept in various centres, and identifies further work needed. It also compiles information on work that is under way in various countries.

Engineering safety review services related to site and external hazards

Country	Site/plant	Service
Indonesia	Muria Peninsula	Siting studies (step 1) — review of quality assurance documents and topical reports (two missions)
Bulgaria	Kozloduy	Seismic safety review — definition of seismic input, specifications and follow-up for the seismic upgrading of units 1–4 (six missions)
Czechoslovakia	Bohunice	Seismic safety review follow-up of upgrading activities
Armenia	Armenia	World Bank and IAEA joint mission to review the energy sector — seismic safety review of the nuclear power plant
Pakistan	Chashma	Review of site safety studies and plant design civil engineering documents
Slovenia	Krško	Review of seismic hazard studies
		Workshop on quality assurance for siting and seismic hazard studies
Tunisia	Tunis	Workshop on quality assurance (work oriented procedures) for siting activities
Malaysia	Siting process	Workshop on quality assurance

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Seismic data for the siting and site revalidation of nuclear facilities	1993	6

CRPs established in the current year

Subject	No. of years	Participating institutions
Management of ageing of in-containment instrument and control cables	3	4
Management of ageing of motor operated isolating valves	3	5
Management of ageing of the concrete containment building	3	6
Management of ageing of the reactor pressure vessel primary nozzle	3	9

Training courses and seminars held

Course name	Location	No. of participants	Duration
Course on fire protection and prevention in nuclear power plants	Spain	12	3 weeks
Course on the safety aspects of ageing and related maintenance in nuclear power plant operation	USA	26	3 weeks

Publications

Series and No.	Title
Safety Series No. 50-P-3	Data collection and record keeping for the management of nuclear power plant ageing
Safety Series No. 50-SG-D2 (Rev.1)	Fire protection in nuclear power plants: A safety guide
Safety Series No. 50-SG-D15	Seismic design and qualification for nuclear power plants
Technical Reports Series No. 338	Methodology for the management of ageing of nuclear power plant components important to safety
IAEA-TECDOC-659	Reactor pressure vessel embrittlement
IAEA-TECDOC-670	Pilot studies on management of ageing of nuclear power plant components: Results of phase I

Operational safety of nuclear power plants

Requirements for the safe operation of nuclear power plants

A draft Safety Guide on the periodic safety review of nuclear power plants was considered at a Technical Committee meeting held in November. This Guide will satisfy, in part, action items from General Conference Resolutions GC(XXXV)/RES/553 and GC(XXXVI)/RES/582 relating to the assessment of the safety level of operating nuclear power plants built to earlier standards.

Operational safety on the basis of PSA insights

During 1992, there was a substantial expansion of activities in the area of the utilization of PSA for optimizing a variety of operational tasks in nuclear power generation. Several meetings were organized to finalize a document on the use of PSA to optimize operational limits and conditions. This document, to be published in 1993, contains a discussion of relevant methodological issues, a review of recent applications worldwide and two case studies that explain in detail the application of the methodology.

PSAPACK is an integrated personal computer based code which includes a number of functions necessary for carrying out a level 1 PSA. The package has been supplemented with a module to support operational safety on the basis of PSA information and results and has been independently tested; an updated and expanded program manual has been prepared. At present, PSAPACK has been distributed to over fifty external users.

Information on unusual events in nuclear power plants

During 1992, information from the Agency's Incident Reporting System (IRS) was used to provide lessons on redundancy, diversity and dependent failures, and on safety culture attributes. In the first stage of an IRS topical study on dependent failure events, a methodology and proposals for further steps were developed.

At an annual meeting of IRS national co-ordinators, the most recent events at nuclear power plants were discussed, as were actions taken in various countries as a result of IRS reports. Enhancement or modification of the IRS database and changes in the IRS classification codes (especially separate categories for the classification of observed and root causes of nuclear power plant events) were also discussed.

Assessment of the safety significance of unusual events in nuclear power plants

At a Technical Committee meeting in March on the International Nuclear Event Scale (INES), it was agreed that the scale, as applied to power reactors, should be presented to Member States with a recommendation for its formal adoption following a trial, and that Member States be informed that an extended scale applicable to all non-reactor nuclear installations was available. It was recommended that Member States be formally invited to participate in this trial, which will run for a period of about one year. In June, a revised and extended INES user's manual and a new leaflet on INES were released.

At an annual Technical Committee meeting of INES national officers in October, the role and composition of the INES Advisory Committee was finalized. The Committee will provide technical advice to ensure consistent application of the user's manual, though no authoritative rating of an event will be given.

As a result of the extension of INES to non-reactor facilities, 47 countries have now joined the INES Information System. Japan confirmed that it is now using INES and the scale is being unofficially applied in France. The USA is using

Assessment of the safety significance of unusual events in nuclear power plants (cont.)

INES to rate a limited number of events. The value of the scale was demonstrated by the response to the event at the RBMK reactor at Sosnovyi Bor, near St. Petersburg, Russia, in March, when a rating was available within a few hours.

Safety performance indicators for nuclear power plants

Agency activities in connection with safety performance indicators focus on three topics: plant specific safety indicators (PSSI), risk based indicators and regulatory safety indicators. The PSSI concept was refined to include comments from potential users. A document was prepared describing PSSI concepts and providing numerous examples; this was reviewed at a Technical Committee meeting in November on the development of predictive safety indicators. Discussions were initiated with several countries to apply the PSSI concept on a trial basis.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Use of PSA in the operation of nuclear power plants	USA	32	2 weeks

Publications

Series and No.	Title
Safety Series No. 50-P-2	In-service inspection of nuclear power plants: A manual
IAEA-INES-92/1	The International Nuclear Event Scale: User's manual

Operational safety services to nuclear power plants

Operational safety review team services

During 1992, there were five Operational Safety Review Team (OSART) missions, four Follow-Up Visits and two Technical Exchange Visits. From 1983, when the first OSART mission was conducted, to the end of 1992, 65 missions to 53 power plant sites in 25 Member States had been completed and 18 Follow-Up Visits had been made.

A consultants meeting was held in June to evaluate the effectiveness of the OSART programme and to consider what improvements were necessary to match the changes in approaches to nuclear safety. It was recognized that the OSART process had matured over the years, remained fundamentally sound and should be continued. There was agreement that the safety culture should be examined in OSART reviews. In fulfilment of this, a pilot exercise was included in an OSART mission. The basis for reviewing safety culture was the Agency's Safety Series No. 75-INSAG-4 and use was made of guidelines prepared for a new possible service, Assessment of Safety Culture in Organizations Team (ASCOT).

Improvements were made in the style of reporting of OSART results. The new procedure is to send the official Agency report, containing a summary of the outcome of the review, to the respective government about two months after the mission. A more explicit report, including the full texts of the proposals for improvement and of the good practices, then follows.

A recent analysis of the results of Follow-Up Visits over the last four years provided a useful indicator of the increasing effectiveness of the OSART programme. In this period, 11 Follow-Up Visits, subsequent to reviews of operational nuclear power plants, took place. The small and declining proportion of proposals that have been withdrawn is one of the indications that OSART missions are becoming better at identifying valid operational issues.

Assessment of Safety Significant Event Team services

In 1992, 18 Assessment of Safety Significant Events Team (ASSET) missions were carried out. The six reviews of operational safety performance carried out at nuclear power plants in France, Hungary, Russia and the United Kingdom by experts from operating and regulatory organizations concluded that the prevention of incidents at these plants showed positive trends over past years, but had not yet reached a satisfactory level because plant management was not capable of detecting all the latent defects in software and hardware. Pending safety issues were identified and specific recommendations were made to prevent incidents (events significant to safety) and failures in operation (through the effectiveness of the plant surveillance programme) and to assist plant management in eliminating the potential root causes of accidents.

OSART/Pre-OSART missions conducted in 1992

Country	Nuclear power plant	Status of plant	Dates
France	Blayais	Operational	13–31 January
France	Fessenheim	Operational	9–27 March
Japan	Fukushima Daini	Operational	23 March–10 April
USA	Grand Gulf	Operational	3–21 August
United Kingdom	Sizewell B	Commissioning (Pre-OSART)	26 October–13 November

Technical Exchange Visits conducted in 1992

Country	Nuclear power plant	Status of plant	Dates
Brazil	Angra 1	Operational	11–15 May
China	Guangdong	Under construction	18–22 May

Follow-Up Visits for OSART/Pre-OSART missions conducted in 1992

Parent mission type	Country	Nuclear power plant	Status of plant	Dates
Pre-OSART	Czechoslovakia	Temelin	Under construction	17–21 February
Safety review	Czechoslovakia	Bohunice	Operational	27–30 April
OSART	Brazil	Angra I	Operational	4–6 May
OSART	Sweden	Ringhals	Operational	2–6 November

Results of OSART Follow-Up Visits, 1989–1992

Period (No. of visits)	No. of issues resolved (%)	No. of issues with satisfactory progress (%)	No. of issues with little or no progress (%)	No. of issues withdrawn (%)	Total No. of issues (%)
1989–1990	219	236	74	18	547
(6)	(40)	(43)	(14)	(3)	(100)
1991–1992	312	200	51	4	567
(5)	(55)	(35)	(9)	(1)	(100)

ASSET training seminars

Location	No. of participants	Duration
Brazil	32	1 week
Bulgaria	28	4 days
Bulgaria	30	1 week
China	36	1 week
Czechoslovakia	29	1 week
Finland	27	1 week
Hungary	22	1 week
Romania	16	1 week
South Africa	32	1 week
Ukraine	27	1 week

Series and No.	Title
IAEA-TECDOC-631	Reviewing reactor engineering and fuel handling: Supplementary guidance and reference material for IAEA OSARTs
IAEA-TECDOC-635	OSART Guidelines, 1992 edition. Reference document for IAEA Operational Safety Review Teams (OSARTs)
IAEA-TECDOC-681	OSART mission highlights, 1989–1990: Operational safety practices in nuclear power plants

Publications

Management and mitigation of accidents in nuclear power plants

Use of computer codes for severe accident analysis

Increasing attention is being focused on extending safety analysis beyond the design basis in order to assess accident prevention and mitigation capabilities (design and operation) in nuclear power plants. The Agency concentrated mostly on severe accident analysis for the WWER-440 and WWER-1000 reactor designs, applying the most advanced methodologies and associated computer codes, and transferring the technology (training, hardware and software) to selected Member States. A report on the use of computer codes for severe accident analysis and simulation is being finalized.

Strategy and procedures for the management of severe accidents

The final version of a guidebook on accident management in nuclear power plants was approved at an Advisory Group meeting. This guidebook is intended to provide a systematic and structured approach to the development and implementation of an accident management programme.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Containment integrity and effectiveness for accident conditions beyond design basis	1993	8
1989	Severe accident management	1993	9

Training courses and seminars held

Course name	Location	No. of participants	Duration
Accident management in nuclear power plant operation	Czechoslovakia Bulgaria	33 50	1 week 1 week
Emergency procedures/accident management	Romania	23	1 week
National course on the management and analysis of severe accidents	Hungary	42	2 weeks

Research reactor safety

Safety standards and guides for research reactors

Progress was made in 1992 on a comprehensive set of Safety Standards and Guides for research reactors. Two Safety Codes (on design and on operation) were submitted to Member States for comments and were then published. The first drafts of one Safety Guide, on commissioning, and three Safety Practices documents, on operating procedures, operational limits and conditions and maintenance, were also prepared. Two Safety Guides on safety assessment and preparation of a safety analysis report, and on utilization and modification were submitted for publication.

Integrated Safety Assessment of Research Reactor services

The Agency continued conducting INSARR (Integrated Safety Assessment of Research Reactors) reviews in 1992. Three research reactors in Peru, Portugal and Turkey were reviewed. In addition, INSARR teams visited research reactors in Argentina, Peru, Romania, Slovenia and Turkey to review the application of safety standards and safety measures.

A draft of a document on guidelines for safety reviews of research reactors was prepared at a consultants meeting in July. This document contains the experience gained by the Agency in conducting INSARR reviews of research reactors. It will be used not only as the basis for such missions, but also for other types of safety evaluations such as peer reviews and regulatory inspections.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Data acquisition for research reactors, PSA studies	1993	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on safety in the operation and utilization of research reactors	France	22	4 weeks
Regional course on safety documentation of research reactors	Bangladesh	13	10 days

Publications

Series and No.	Title
Safety Series No. 35-S1	Code on the safety of research reactors: Design
Safety Series No. 35-S2	Code on the safety of research reactors: Operation
IAEA-TECDOC-636	Manual on reliability data collection for research reactor PSAs

Safety assessment of nuclear facilities

Probabilistic safety assessment techniques

Since current PSAs, with a few exceptions, do not include modelling of accident sequences during shutdown and low power conditions, a draft report providing an overview of this area was prepared. It was reviewed at a Technical Committee meeting in Stockholm on shutdown risk. Numerous recommendations were made, including a suggestion to develop an international guidance document on the topic. This document will be finalized during the first half of 1993.

In order to complete the Agency's PSA programme on nuclear facilities other than nuclear power plants, a status report on PSA methodology, techniques and applications was elaborated. The report contains a review of the experience from PSAs for different types of facilities, a structured framework for conducting a PSA for non-reactor nuclear facilities and recommendations for further work in this field.

Work has begun to establish the type and structure of PSA information and the results to be compiled and implemented in a comprehensive information system. This system is intended to permit easy and interactive access to a PSA database. It will include a report generation module to produce comparative tables and diagrams.

A Technical Committee meeting on advances in reliability analysis and PSA was held in September in Budapest, Hungary. Discussion was concentrated on the use of plant specific PSAs for the optimization of operational tasks (including maintenance) and the prospects for the wider use of PSA in the actual licensing of nuclear power plants.

Guidelines for PSA

There was an International Peer Review Service (IPERS) mission to the Mühleberg nuclear power plant in Switzerland. It was the first review with a restricted scope and covered a specific aspect, fire analysis, in the PSA of the plant. In February, a team of five specialists conducted a phase 2 review of the PSA for the Dodewaard nuclear power plant in the Netherlands. In September, a PSA workshop was organized to review a level 1 PSA for the Kola 1 WWER-440 nuclear power plant in Russia.

The IPERS missions are using the Agency's PSA review guideline as a basis. This guideline was first published in 1990. It is intended to update this document periodically in order to include the experiences gained during IPERS missions and to reflect the progress made in PSA techniques. A final draft report of the second version of this guideline was reviewed and will soon be published. This version has been expanded to include guidance for level 2 PSA reviews.

In order to expand the Agency's PSA procedures, a Technical Committee meeting was held on procedures for a level 2 PSA. A draft report on this meeting will be circulated for comment and published in the Agency's Safety Series.

Safety impact of human reliability

Experience from past PSAs has shown that there is a need for basic human reliability data that reflect the environment in the plant under consideration. In a draft report, a user oriented structure for collecting, evaluating and applying human reliability data was defined. This structure will complement the procedure for conducting human reliability analysis in PSA. However, further work is needed to include specific case studies or applications.

Safety impact of human reliability (cont.)

A possible new safety service was tested in 1992, the Assessment of Safety Culture in Organizations Team (ASCOT). This service reviews the effectiveness of safety culture based on the principles and recommendations contained in the Agency's Safety Series No. 75-INSAG-4. Guidelines have been developed, which may also be used by any organization wishing to assess its own safety culture without an ASCOT review mission. Three types of ASCOT services are envisaged: a stand-alone ASCOT mission; ASCOT services combined with other Agency services such as ASSET, OSART or IRRT missions; and ASCOT Advisory Services, which would arrange with the recipient country for a future self-assessment of safety culture. In November, the ASCOT guidelines were tested during an OSART review of the Sizewell B nuclear power plant in the United Kingdom.

Hardware reliability

Improvement in the reliability of safety and other equipment is still one of the primary tasks at every nuclear power plant. Maintenance practices play a major role in improving the reliability of safety and other equipment. At a Technical Committee meeting, a variety of issues were discussed, including the United States Nuclear Regulatory Commission maintenance rule and reliability centred maintenance concepts.

Data on hardware reliability is essential to support a variety of safety assessment programmes. The Agency's activities during 1992 included finalization of multipurpose in-plant data collection procedures, discussion of problems related to the selection of data and data processing, and preliminary activities to initiate a programme that will deal with common cause data collection and analysis.

Reliability of computerized safety systems

The Agency continued to promote recognition of the need to upgrade vital control and protection systems. In October, 30 experts gathered to discuss the problems and future trends in the use and licensing of computerized safety systems as a modernization technique.

The first draft of a technical report on the state of the art in software important to safety in nuclear power plants was discussed at a Technical Committee meeting in June. This document will also serve as a technical basis for the development of a Safety Guide on software.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Development of safety related expert systems	1993	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Use of PSA in the operation of nuclear power plants: Risk based prioritization of operational tasks	USA	23	3 weeks

Publications

Series and No.	Title
Proceedings Series	Probabilistic safety assessment for operational safety — PSA 91
Safety Series No. 50-P-4	Procedures for conducting probabilistic safety assessments of nuclear power plants
Safety Series No. 106	The role of probabilistic safety assessment and probabilistic safety criteria in nuclear power plant safety
IAEA-TECDOC-648	Procedures for conducting common cause failure analysis in probabilistic safety assessment
IAEA-TECDOC-658	Safety related maintenance in the framework of the reliability centred maintenance concept
IAEA-TECDOC-660	Expert systems in the nuclear industry
IAEA-TECDOC-669	Case study on the use of PSA methods: Assessment of technical specifications for reactor protection system instrumentation
IAEA-TECDOC-672	Safety aspects of nuclear power plant automation and robotics

Extrabudgetary programmes

Safety of WWER-440 Model 230 plants

In early 1992, the Agency published a document containing an overview and major findings of the extrabudgetary programme on the safety of WWER-440 Model 230 nuclear power plants. Whereas the first phase of this programme dealt with the results of safety review missions to all such plants, the second phase of the programme, currently in progress, focuses on assisting Member States in planning and evaluating modifications (as regards both hardware and the conduct of operations) and to verify that proposed modifications respond to concerns identified during the programme's first phase. A report is being prepared containing a compilation of safety improvements proposed and/or adopted in Bulgaria, Czechoslovakia and Russia in response to safety issues identified by the Agency.

In response to a request from the Bulgarian Government, the Agency reviewed a study of the risk impact of short and long term safety measures proposed for the Kozloduy nuclear power plant. Follow-up missions to assess the status of safety improvements are also being conducted.

Generic studies on safety issues common to all WWER-440 Model 230 plants are under way, the objective being to provide an overview of each issue and to assess what work must still be done. The Agency prepared status reports on two issues: reactor pressure vessel embrittlement and the applicability of the LBB concept. A document containing technical guidance for assessing the instrumentation and control systems at WWER-440 Model 230 plants was also prepared.

Safety of WWER-1000 plants

In June, the Agency convened a consultants meeting to collect and review available information and to prepare the technical basis for the formulation of a programme dedicated to WWER-1000 plants. The safety issues identified as being important for WWER-1000 plants included the integrity of steam generators, the applicability of LBB, core power stability, and instrumentation and control. Various methods were suggested of ensuring full use of the expertise of design organizations and plant operators and of institutions in various countries in western Europe and elsewhere. On the basis of requests from countries operating and constructing WWER-1000 nuclear power plants, the Agency established a safety programme for this type of reactor.

Safety of RBMK plants

At a Technical Committee meeting on RBMK safety in April, it was agreed that co-ordinated efforts were urgently required to implement improvements at these plants. As a result, the Agency announced the initiation of an international programme on the safety assessment of RBMK reactors. The programme will include a safety review of proposed modifications, specialists meetings on specific topics and missions to assess plant specific design features, operational practices, safety significant events and seismic safety.

There were ASSET missions to the Chernobyl and Kursk nuclear power plants, and other missions are scheduled to all operating RBMKs. A meeting to review proposed safety modifications was held in October. The objective was to discuss the scope and results of the safety evaluations carried out and the technical basis for the safety improvements implemented and planned for RBMK reactors. The areas reviewed included core monitoring and control, pressure boundary integrity, accident mitigation and the electric power supply.

Publications

Series and No.	Title
Special publication	An overview and major findings of the IAEA extrabudgetary programme on the safety of WWER-440 Model 230 nuclear power plants
IAEA-TECDOC-640	Ranking of safety issues for WWER-440 Model 230 nuclear power plants

SAFEGUARDS

Safeguards statement

In carrying out the safeguards obligations of the Agency in 1992, the Secretariat did not detect any event which would indicate the diversion of a significant amount of nuclear material, or the misuse of facilities, equipment or non-nuclear material which had been placed under Agency safeguards for the manufacture of any nuclear weapon, or for any other military purpose, or for the manufacture of any other nuclear explosive device or for purposes unknown.[1] *On the basis of all the information available to the Agency, it is considered reasonable to conclude that nuclear material and other items which had been placed under Agency safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for.*[2] *In pursuit of the Agency's task to verify the correctness and assess the completeness of State declarations, inspections were carried out, inter alia, in the Democratic People's Republic of Korea (DPRK) and in South Africa. In the case of the DPRK, it was concluded that the Agency could not confirm the correctness and completeness of the DPRK's initial report, and for this reason the Agency subsequently requested access to additional information and sites.*

Programme overview

In accordance with General Conference Resolution GC(XXXV)/RES/567 and with United Nations General Assembly Resolution A/RES/46/34A, a programme of inspections was undertaken to verify the completeness of the inventory of South Africa's nuclear installations and material. The results of these inspections as reported to the General Conference contained the general conclusions that the verification activities had found no evidence that the list of facilities (and locations outside facilities) or the inventory of nuclear material, included in the initial report, was incomplete.

A safeguards agreement pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) entered into force in April with the Democratic People's Republic of Korea. As a result, several new facilities, some of a complex nature, became subject to safeguards. Inspection missions were performed in order to verify the correctness and completeness of the State's initial inventory declaration. The task was still continuing at the end of the year and a number of apparent inconsistencies are under consideration.

On 28 April, Commissioner Cardoso e Cunha of the CEC and the Director General of the Agency signed a document entitled "Effective and Efficient Implementation of Safeguards by the IAEA and EURATOM under the Agreement (INFCIRC/193)". This document endorsed a new 'partnership approach' on the implementation of safeguards in the European Community by the Agency and EURATOM under the provisions of the safeguards agreement between the European Community, its non-nuclear weapon Member States and the Agency. EURATOM and the Agency established a technical working group to prepare the necessary practical arrangements for implementing the new partnership approach.

An action plan was prepared in readiness for the application of safeguards in the newly independent States of the former USSR. The action includes technical support to States, technical visits related to the installation of safeguards equipment and verification of nuclear material. The first technical

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[1] *In the case of voluntary-offer agreements with nuclear-weapon States (as defined in NPT), nuclear material subject to safeguards was not withdrawn from safeguards except in conformity with these agreements.*

[2] *The probability of detecting a dviersion of nuclear material in an amount less than one significant quantity is lower than that of detecting a diversion of one significant quantity. The probability depends on the amount of nuclear material concerned and the technical measures and the resources available.*

visits were undertaken to Lithuania, Kazakhstan and Ukraine. Fact finding missions also visited Belarus, Kazakhstan and Ukraine.

A number of measures were proposed, discussed and approved by the Board of Governors for the strengthening of safeguards (special inspections, early provision and use of design information, reporting on the import and export of nuclear material and specified equipment and non-nuclear material).

Work was initiated on the development of a computerized system for the storage and retrieval of information derived from open sources (public media and scientific literature). This was undertaken to strengthen safeguards through more systematic collection and analysis of such information. A prototype system was implemented.

The LASCAR (Large Scale Reprocessing Plant Safeguards) project was successfully completed after a four-year study. The final report summarizing all the essential results was issued in July. The general conclusion of the study is that a wide range of techniques are currently available or are being introduced for safeguarding large scale reprocessing plants effectively and efficiently. Appropriate combinations of these techniques, selected on a plant specific basis, will enable the successful implementation of effective safeguards at large reprocessing plants whose designs were considered by LASCAR.

Owing to financial constraints in 1992, inspection goals for a number of depleted, natural and low enriched uranium fuel fabrication and conversion plants were not attained. No inspections were performed in two nuclear-weapon States under the terms of their voluntary-offer agreements. Inspections were performed in one of them to verify material removed from Iraq under the terms of United Nations Security Council Resolution 687.

Several Advisory Group and consultants meetings had to be postponed. This resulted in a deterioration of the ability to maintain contacts with developers of new equipment and procedures in Member States, to keep abreast of technological developments and to keep up to date with developments in related fields of potential value to the safeguards system. The provision of equipment maintenance and calibration services was reduced. The limited availability of travel funds restricted the amount of preventive maintenance and servicing of equipment installed in nuclear facilities.

As of 31 December 1992, 188 safeguards agreements were in force with 110 States (and with Taiwan, China), compared to 180 agreements with 105 States (and with Taiwan, China) at the end of 1991.

Safeguards agreements pursuant to NPT entered into force with:

St. Vincent and the Grenadines, in January;
the Democratic People's Republic of Korea, in April;
the Syrian Arab Republic, in May;
Malawi, in August;
Lithuania, in October;
Trinidad and Tobago, in November.

A project agreement with the Syrian Arab Republic, covering the supply of a miniature neutron source reactor and enriched uranium by China, entered into force in May. A unilateral submission agreement with Algeria for the application of safeguards to a research reactor supplied by China entered into force in June.

The Board of Governors approved draft safeguards agreements pursuant to NPT with Cameroon, Estonia and the United Republic of Tanzania. It also approved an agreement with the United Kingdom and EURATOM pursuant to Additional Protocol I to the Treaty of Tlatelolco, three project agreements with Indonesia covering the supply of enriched uranium and a unilateral submission agreement by Pakistan for the application of safeguards to a nuclear power reactor supplied by China. None of these agreements had entered into force at the end of 1992. In addition, there were 13 agreements

pursuant to NPT, 2 project agreements and an agreement with Argentina, Brazil and the Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), all of which had been approved by the Board of Governors but none of which had entered into force at the end of 1992.

During 1992, safeguards were applied in 44 States under agreements pursuant to NPT or to NPT and the Treaty of Tlatelolco, in one State under an agreement pursuant to the Treaty of Tlatelolco and in ten States under INFCIRC/66/Rev.2-type agreements; at the end of 1992, safeguards in one of these ten States were being applied pursuant to NPT. Preliminary visits were made in one State with which a safeguards agreement pursuant to NPT entered into force late in the year. Safeguards activities pursuant to NPT in Iraq continued to be subsumed by activities pursuant to Security Council Resolution 687. (The Agency also applies safeguards to nuclear installations in Taiwan, China.)

Each State that concludes a comprehensive safeguards agreement with the Agency undertakes to accept "safeguards in accordance with the terms of the agreement, on all source or special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction or carried out under its control anywhere". Safeguards agreements based on INFCIRC/66/Rev.2 require that safeguards be applied to the nuclear material, facilities, equipment and non-nuclear material — and with regard to certain technological information — specified in them. In the case of nuclear-weapon States, safeguards agreements do not provide for safeguards on all nuclear material, and these States have unsafeguarded nuclear facilities. The Agency believes that there were nine States with significant nuclear activities but without any safeguards agreement in force at the end of 1992.

Voluntary-offer agreements were in force with the five nuclear-weapon States. Inspection effort related to these States was minimized in 1992. First inspections were carried out in one State under the agreement with that State, and material removed from Iraq under the terms of Security Council Resolution 687 was inspected in another State. Facilities of particular safeguards importance were designated and inspected in two States. In one nuclear-weapon State, safeguards were also applied at some facilities under INFCIRC/66/Rev.2-type agreements.

China and France acceded to NPT in 1992. All five nuclear-weapon States are now Parties to the Treaty.

As of 31 December 1992, safeguards agreements were in force with 94 States pursuant to NPT. For 55 non-nuclear-weapon States party to NPT there is still no safeguards agreement in force in accordance with Article III.4 of the Treaty. As far as the Agency is aware, only three of these States have significant nuclear activities. Safeguards were being applied in two of these States pursuant to other safeguards agreements, and technical arrangements are under discussion with the third State pending the entry into force of a safeguards agreement pursuant to NPT.

NPT safeguards agreements have already been concluded with all eleven signatories of the South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty), and safeguards were applied in one of these States pursuant to such an agreement.

Twenty of the 24 Latin American States party to the Treaty of Tlatelolco have concluded agreements with the Agency pursuant to that Treaty and 17 of these agreements are in force. Safeguards agreements pursuant to Additional Protocol I of the Treaty of Tlatelolco are in force with two States with territories in the zone of application of the Treaty, and a similar agreement with a third such State has been approved by the Board of Governors.

In Resolution 687, adopted by the Security Council of the United Nations in April 1991, the Agency was requested to carry out with the assistance and co-operation of the Special Commission of the United Nations immediate on-site inspection of Iraq's nuclear capabilities and to develop and carry out a plan for the destruction, removal or rendering harmless, as appropriate, of all nuclear weapons and nuclear-weapons-usable material or any subsystems or components or any research, development, support or manufacturing facilities related thereto. It also required the Agency to develop for the approval of the Security Council a plan for the future ongoing monitoring and verification of

Iraq's compliance with its obligations under Resolution 687, including an inventory of all nuclear material in Iraq subject to the Agency's verification and inspections to confirm that the Agency's safeguards cover all relevant nuclear activities in Iraq.

During 1992 the Agency carried out 8 inspections in Iraq, bringing the total number of inspections to 16, and implemented the essential elements of the plan for the destruction, removal or rendering harmless of the items indicated in the Resolution, including the large Iraqi facilities at Al Atheer, Ash Sharqat and Tarmiya. One major outstanding item is the removal of the high enriched uranium contained in the irradiated fuel elements of the Iraqi nuclear research reactors still stored in Iraq under Agency custody. Negotiations are continuing with the Russian Federation for the removal of this material, which is likely to take place in the course of 1993.

In a view of the Iraqi authorities' persistent refusal to disclose information related to foreign suppliers of equipment, material and technical advice used in activities prohibited under Security Council Resolution 687, the Agency has sought assistance from Member States to verify the correctness and completeness of its inspection results.

The Agency's inspections are also progressively phasing in elements of the future ongoing monitoring and verification plan of Iraq's compliance with Security Council Resolutions 687 and 707. A radiometric survey of the main water bodies of Iraq was completed in the course of 1992 to obtain a baseline against which future measurements of the radioactivity level will be compared.

Number of States having significant nuclear activities at the end of the year indicated

	Number of States		
	1990	*1991*	*1992*
States with safeguards applied under NPT or NPT/Tlatelolco agreements	*42*	*43*	*45[a]*
States with safeguards applied under Tlatelolco agreements	*1*	*1*	*1*
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[b]	*9*	*8*	*8*
Nuclear-weapon States with safeguards applied under voluntary-offer agreements	*4*	*4*	*5*
States without any safeguards agreement in force	*—*	*—*	*9*
Total number of States with significant nuclear activities	*57*	*57*	*68*

[a] *This excludes Iraq, where safeguards activities in 1992 continued to be subsumed by activities carried out pursuant to Security Council Resolution 687.*

[b] *Some States with INFCIRC/66/Rev.2-type agreements which have not yet been suspended, although NPT agreements have entered into force, are listed under NPT agreements only. Nuclear-weapon States with INFCIRC/66/Rev.2-type agreements in force are not included. Safeguards are also applied to nuclear installations in Taiwan, China.*

Situation on 31 December 1992 with respect to the conclusion of safeguards agreements between the Agency and non-nuclear-weapon States in connection with NPT

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	*Date of ratification, accession or succession*[a] (2)	*Safeguards agreement with the Agency* (3)	*INFCIRC* (4)
Afghanistan	*4 February 1970*	*In force: 20 February 1978*	*257*
Albania	*12 September 1990*		
Antigua and Barbuda[b]	*1 November 1981*	*Signed: 1 February 1990*	
Australia	*23 January 1973*	*In force: 10 July 1974*	*217*
Austria	*27 June 1969*	*In force: 23 July 1972*	*156*
Azerbaijan	*22 September 1992*		
Bahamas	*10 July 1973*		
Bahrain	*5 November 1988*		
Bangladesh	*27 September 1979*	*In force: 11 June 1982*	*301*
Barbados	*21 February 1980*		
Belgium	*2 May 1975*	*In force: 21 February 1977*	*193*
Belize	*9 August 1985*	*Signed: 13 August 1992*	
Benin	*31 October 1972*		
Bhutan	*23 May 1985*	*In force: 24 October 1989*	*371*
Bolivia[b]	*26 May 1970*	*Signed: 23 August 1974*	
Botswana	*28 April 1969*		
Brunei Darussalam	*25 March 1985*	*In force: 4 November 1987*	*365*
Bulgaria	*5 September 1969*	*In force: 29 February 1972*	*178*
Burkina Faso	*3 March 1970*		
Burundi	*19 March 1971*		
Cambodia	*2 June 1972*		
Cameroon	*8 January 1969*	*Signed: 21 May 1992*	
Canada	*8 January 1969*	*In force: 21 February 1972*	*164*
Cape Verde	*24 October 1979*		
Central African Republic	*25 October 1970*		
Chad	*10 March 1971*		
Colombia	*8 April 1986*		
Congo	*23 October 1978*		
Costa Rica[b]	*3 March 1970*	*In force: 22 November 1979*	*278*
Côte d'Ivoire	*6 March 1973*	*In force: 8 September 1983*	*309*
Cyprus	*10 February 1970*	*In force: 26 January 1973*	*189*
Czechoslovakia	*22 July 1969*	*In force: 3 March 1972*	*173*
Democratic People's Republic of Korea	*12 December 1985*	*In force: 10 April 1992*	*403*
Denmark[c]	*3 January 1969*	*In force: 21 February 1977*	*193*
Dominica	*10 August 1984*		
Dominican Republic[b]	*24 July 1971*	*In force: 11 October 1973*	*201*
Ecuador[b]	*7 March 1969*	*In force: 10 March 1975*	*231*
Egypt	*26 February 1981*	*In force: 30 June 1982*	*302*
El Salvador[b]	*11 July 1972*	*In force: 22 April 1975*	*232*
Equatorial Guinea	*1 November 1984*	*Approved by the Board, June 1986*	

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Estonia	31 January 1992	Approved by the Board, Feb. 1992	
Ethiopia	5 February 1970	In force: 2 December 1977	261
Fiji	14 July 1972	In force: 22 March 1973	192
Finland	5 February 1969	In force: 9 February 1972	155
Gabon	19 February 1974	Signed: 3 December 1979	
Gambia	12 May 1975	In force: 8 August 1978	277
Germany[d]	2 May 1975	In force: 21 February 1977	193
Ghana	5 May 1970	In force: 17 February 1975	226
Greece[e]	11 March 1970	Accession: 17 December 1981	193
Grenada	19 August 1974		
Guatemala[b]	22 September 1970	In force: 1 February 1982	299
Guinea	29 April 1985		
Guinea-Bissau	20 August 1976		
Haiti[b]	2 June 1970	Signed: 6 January 1975	
Holy See	25 February 1971	In force: 1 August 1972	187
Honduras[b]	16 May 1973	In force: 18 April 1975	235
Hungary	27 May 1969	In force: 30 March 1972	174
Iceland	18 July 1969	In force: 16 October 1974	215
Indonesia	12 July 1979	In force: 14 July 1980	283
Iran, Islamic Republic of	2 February 1970	In force: 15 May 1974	214
Iraq	29 October 1969	In force: 29 February 1972	172
Ireland	1 July 1968	In force: 21 February 1977	193
Italy	2 May 1975	In force: 21 February 1977	193
Jamaica[b]	5 March 1970	In force: 6 November 1978	265
Japan	8 June 1976	In force: 2 December 1977	255
Jordan	11 February 1970	In force: 21 February 1978	258
Kenya	11 June 1970		
Kiribati	18 April 1985	In force: 19 December 1990	390
Korea, Republic of	23 April 1975	In force: 14 November 1975	236
Kuwait	17 November 1989		
Lao People's Democratic Republic	20 February 1970	Signed: 22 November 1991	
Lebanon	15 July 1970	In force: 5 March 1973	191
Lesotho	20 May 1970	In force: 12 June 1973	199
Liberia	5 March 1970		
Libyan Arab Jamahiriya	26 May 1975	In force: 8 July 1980	282
Liechtenstein	20 April 1978	In force: 4 October 1979	275
Lithuania	23 September 1991	In force: 15 October 1992	413
Luxembourg	2 May 1975	In force: 21 February 1977	193
Madagascar	8 October 1970	In force: 14 June 1973	200
Malawi	18 February 1986	In force: 3 August 1992	409
Malaysia	5 March 1970	In force: 29 February 1972	182
Maldives	7 April 1970	In force: 2 October 1977	253
Mali	10 February 1970		
Malta	6 February 1970	In force: 13 November 1990	387
Mauritius	25 April 1969	In force: 31 January 1973	190

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Mexico[b]	21 January 1969	In force: 14 September 1973	197
Mongolia	14 May 1969	In force: 5 September 1972	188
Morocco	27 November 1970	In force: 18 February 1975	228
Mozambique	4 September 1990		
Myanmar	2 December 1992		
Namibia	2 October 1992		
Nauru	7 June 1982	In force: 13 April 1984	317
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands[f]	2 May 1975	In force: 21 February 1977	193
New Zealand	10 September 1969	In force: 29 February 1972	185
Nicaragua[b]	6 March 1973	In force: 29 December 1976	246
Niger	9 October 1992		
Nigeria	27 September 1968	In force: 29 February 1988	358
Norway	5 February 1969	In force: 1 March 1972	177
Panama[b]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	25 January 1982	In force: 13 October 1983	312
Paraguay[b]	4 February 1970	In force: 20 March 1979	279
Peru[b]	3 March 1970	In force: 1 August 1979	273
Philippines	5 October 1972	In force: 16 October 1974	216
Poland	12 June 1969	In force: 11 October 1972	179
Portugal[g]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
St. Lucia	28 December 1979	In force: 2 February 1990	379
St. Vincent and the Grenadines	6 November 1984	In force: 8 January 1992	400
Samoa	17 March 1975	In force: 22 January 1979	268
San Marino	10 August 1970	Approved by the Board, Feb.1977	
São Tome and Principe	20 July 1983		
Saudi Arabia	3 October 1988		
Senegal	17 December 1970	In force: 14 January 1980	276
Seychelles	12 March 1985		
Sierra Leone	26 February 1975	Signed: 10 November 1977	
Singapore	10 March 1976	In force: 18 October 1977	259
Slovenia[b]	7 April 1992		
Solomon Islands	17 June 1981	Signed: 28 March 1991	
Somalia	5 March 1970		
South Africa	10 July 1991	In force: 16 September 1991	394
Spain	5 November 1987	Accession: 5 April 1989	193
Sri Lanka	5 March 1979	In force: 6 August 1984	320
Sudan	31 October 1973	In force: 7 January 1977	245
Suriname[b]	30 June 1976	In force: 2 February 1979	269
Swaziland	11 December 1969	In force: 28 July 1975	227
Sweden	9 January 1970	In force: 14 April 1975	234
Switzerland	9 March 1977	In force: 6 September 1978	264

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Syrian Arab Republic	24 September 1969	In force: 18 May 1992	407
Thailand	7 December 1972	In force: 16 May 1974	241
Togo	26 February 1970	Signed: 29 November 1990	
Tonga	7 July 1971	Approved by the Board, Feb 1975	
Trinidad and Tobago[b]	30 October 1986	In force: 4 November 1992	414
Tunisia	26 February 1970	In force: 13 March 1990	381
Turkey	17 April 1980	In force: 1 September 1981	295
Tuvalu	19 January 1979	In force: 15 March 1991	391
Uganda	20 October 1982		
United Republic of Tanzania	7 June 1991	Signed: 26 August 1992	
Uruguay[b]	31 August 1970	In force: 17 September 1976	157
Uzbekistan	7 May 1992		
Venezuela[b]	26 September 1975	In force: 11 March 1982	300
Viet Nam	14 June 1982	In force: 23 February 1990	376
Yemen, Republic of	1 June 1979		
Yugoslavia	3 March 1970	In force: 28 December 1973	204
Zaire	4 August 1970	In force: 9 November 1972	183
Zambia	15 May 1991		
Zimbabwe	26 September 1991		

[a] The information reproduced in columns (1) and (2) was provided to the Agency by depository Governments of NPT, and an entry in column (1) does not imply the expression of any opinion on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers. The Table does not contain information relating to the participation of Taiwan, China, in NPT.

[b] The relevant safeguards agreement refers to both NPT and the Treaty of Tlatelolco.

[c] The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands. Upon Greenland's secession from EURATOM as of 31 January 1985, the Agreement between the Agency and Denmark (INFCIRC/176) re-entered into force as to Greenland.

[d] The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.

[e] The application of Agency safeguards in Greece under the agreement INFCIRC/166, provisionally in force since 1 March 1972, was suspended on 17 December 1981, on which date Greece acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.

[f] An agreement had also been concluded in respect of the Netherlands Antilles (INFCIRC/229). This agreement entered into force on 5 June 1975.

[g] The NPT safeguards agreement with Portugal (INFCIRC/272), in force since 14 June 1979, was suspended on 1 July 1986, on which date Portugal acceded to the agreement between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency of 5 April 1973 (INFCIRC/193).

[h] The NPT safeguards agreement concluded with Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in Slovenia to the extent relevant to the territory of Slovenia.

Situation on 31 December 1992 with respect to the conclusion of safeguards agreements between the Agency and States party to the Treaty of Tlatelolco[a]

States party to the Treaty of Tlatelolco (1)	Date of becoming a party to the Treaty of Tlatelolco (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Antigua and Barbuda[b]	11 October 1983	Signed: 1 February 1990	
Bahamas	26 April 1977		
Barbados	25 April 1969		
Bolivia[b]	18 February 1969	Signed: 23 August 1974	
Colombia	6 September 1972	In force: 22 December 1982	306
Costa Rica[b]	25 August 1969	In force: 22 November 1979	276
Dominican Republic[b]	14 June 1968	In force: 11 October 1973	201
Ecuador[b]	11 February 1969	In force: 10 March 1975	231
El Salvador[b]	22 April 1968	In force: 22 April 1975	232
Grenada	20 June 1975		
Guatemala[b]	6 February 1970	In force: 1 February 1982	299
Haiti[b]	23 May 1969	Signed: 6 January 1975	
Honduras[b]	23 September 1968	In force: 18 April 1975	235
Jamaica[b]	26 June 1969	In force: 6 November 1978	265
Mexico[b, c]	20 September 1967	In force: 14 September 1973	197
Nicaragua[b]	24 October 1968	In force: 29 December 1976	246
Panama[d]	11 June 1971	In force: 23 March 1984	316
Paraguay[b]	19 March 1969	In force: 20 March 1979	279
Peru[b]	4 March 1969	In force: 1 August 1979	273
St. Vincent and the Grenadines	14 February 1992		
Suriname[b]	10 June 1977	In force: 2 February 1979	269
Trinidad and Tobago[b]	27 June 1975	In force: 4 November 1992	414
Uruguay[b]	20 August 1968	In force: 17 September 1976	157
Venezuela[b]	23 March 1970	In force: 11 March 1982	300
In addition, there are the following safeguards agreements with States party to Additional Protocol I to the Treaty:[e]			
	Netherlands[b]	In force: 5 June 1975	229
	United Kingdom	Approved by the Board, Sept 1992	
	United States of America	In force: 6 April 1989	366

[a] The information reproduced in columns (1) and (2) was taken from the relevant OPANAL status report.

In addition to the States listed in column (1), Argentina has signed the Treaty but not ratified it, while Brazil and Chile have ratified it but have not yet become parties to the Treaty as they have not so far made the declaration provided for in Article 28 of the Treaty. Dominica signed the Treaty on 2 May 1989, Belize signed the Treaty on 14 February 1992 and St. Lucia did so on 25 August 1992.

[b] The relevant safeguards agreement refers to both the Treaty of Tlatelolco and NPT.

[c] The application of safeguards under an agreement with Mexico in connection with the Treaty of Tlatelolco which entered into force on 6 September 1968 (INFCIRC/118) was suspended after the conclusion of an agreement with Mexico in connection with both the Treaty of Tlatelolco and NPT (INFCIRC/197).

[d] An agreement has also been concluded in 1988 pursuant to both the Treaty of Tlatelolco and NPT; this has not yet entered into force.

[e] Additional Protocol I refers to States outside Latin America which have de jure or de facto jurisdiction over territories within the limits of the geographical zone established in the Treaty.

Agreements providing for safeguards, other than those in connection with NPT or the Treaty of Tlatelolco, approved by the Board as of 31 December 1992

Party(ies)[a]	*Subject*	*Entry into force*	*INFCIRC*
(While the Agency is a party to each of the following agreements, only the State(s) party to them is (are) listed.)			
(i) Project agreements			
Albania	*Research reactor and fuel therefor*	*Approved by the Board, June 1991*	
Argentina	*Siemens SUR-100*	*13 March 1970*	*143*
	RAEP Reactor	*2 December 1964*	*62*
Chile	*Herald Reactor*	*19 December 1969*	*137*
Finland[b]	*FIR-1 Reactor*	*30 December 1960*	*24*
	FINN sub-critical assembly	*30 July 1963*	*53*
Ghana	*Research reactor and fuel therefor*	*Approved by the Board, Dec 1991*	
Greece[b]	*GRR-1 Reactor*	*1 March 1972*	*163*
Indonesia[b]	*Additional core-load for TRIGA Reactor*	*19 December 1969*	*136*
	Enriched uranium for materials test reactor fuel development	*Approved by the Board, Dec 1992*	
	Enriched uranium for the fabrication of isotope production targets	*Approved by the Board, Dec 1992*	
Iran, Islamic Republic of[b]	*UTRR Reactor*	*10 May 1967*	*97*
Jamaica[b]	*Fuel for research reactor*	*25 January 1984*	*315*
Japan[b]	*JRR-3*	*24 March 1959*	*3*
Malaysia[b]	*TRIGA-II Reactor*	*22 September 1980*	*287*
Mexico[b]	*TRIGA-III Reactor*	*18 December 1963*	*52*
	Siemens SUR-100	*21 December 1971*	*162*
	Laguna Verde Nuclear Power Plant	*12 February 1974*	*203*
Morocco[b]	*Fuel for research reactor*	*2 December 1983*	*313*
Pakistan	*PRR Reactor*	*5 March 1962*	*34*
	Booster rods for KANUPP	*17 June 1968*	*116*
Peru[b]	*Research reactor and fuel therefor*	*9 May 1978*	*266*
Philippines[b]	*PRR-1 Reactor*	*28 September 1966*	*88*
Romania[b]	*TRIGA Reactor*	*30 March 1973*	*206*
	Experimental fuel elements	*1 July 1983*	*307*
Spain[b]	*Coral-I Reactor*	*23 June 1967*	*99*
Syrian Arab Republic[b]	*Miniature neutron source reactor and enriched uranium*	*18 May 1992*	*408*
Thailand[b]*/United States of America*	*Fuel for research reactor*	*30 September 1986*	*342*
Turkey[b]	*Sub-critical assembly*	*17 May 1974*	*212*
Uruguay[b]	*URR Reactor*	*24 September 1965*	*67*
Venezuela[b]	*RV-1 Reactor*	*7 November 1975*	*238*
Viet Nam[b]	*Fuel for research reactor*	*1 July 1983*	*308*
Yugoslavia[b]	*TRIGA-II Reactor*	*4 October 1961*	*32*
	Krško Nuclear Power Plant	*14 June 1974*	*213*
Zaire[b]	*TRICO Reactor*	*27 June 1962*	*37*
	Fuel for research reactor	*20 September 1990*	*389*
(ii) Unilateral submissions			
Albania	*All nuclear material and facilities*	*25 March 1988*	*359*
Algeria	*Nur research reactor*	*9 April 1990*	*361*
	Es Salam research reactor	*2 June 1992*	*401*
Argentina	*Atucha Power Reactor Facility*	*3 October 1972*	*168*
	Nuclear material	*23 October 1973*	*202*
	Embalse Power Reactor Facility	*6 December 1974*	*224*

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Argentina (cont.)	Equipment and nuclear material	22 July 1977	250
	Nuclear material, material, equipment and facilities	22 July 1977	251
	Atucha II Nuclear Power Plant	15 July 1981	294
	Heavy water plant	14 October 1981	296
	Heavy water	14 October 1981	297
	Nuclear material	8 July 1982	303
Chile	Nuclear material	31 December 1974	256
	Nuclear material	22 September 1982	304
	Nuclear material	18 September 1987	350
Cuba	Nuclear research reactor and fuel therefor	25 September 1980	298
	Nuclear power plant and nuclear material	5 May 1980	281
	Zero-power nuclear reactor and fuel therefor	7 October 1983	311
Democratic People's Republic of Korea	Research reactor and nuclear material for this reactor[c]	20 July 1977	252
India	Nuclear material, material and facilities	17 November 1977	260
	Nuclear power station	27 September 1988	360
	Nuclear material	11 October 1989	374
Pakistan	Nuclear material	2 March 1977	248
	Miniature neutron source reactor	10 September 1991	393
	Nuclear power reactor	Approved by the Board, June 1992	
Spain	Nuclear material[c]	18 June 1975	221
	Vandellos Nuclear Power Plant[c]	11 May 1981	292
	Specified nuclear facilities[c]	11 May 1981	291*
United Kingdom	Nuclear material	14 December 1972	175
Viet Nam	Research reactor and fuel therefor[c]	12 June 1981	293
(iii) Agreements concluded with nuclear-weapon States on the basis of voluntary offers			
China	Nuclear material in facilities selected from list of facilities provided by China	18 September 1989	369
France	Nuclear material in facilities submitted to safeguards	12 September 1981	290
Russian Federation	Nuclear material in facilities selected from list of facilities provided by the Russian Federation	10 June 1985	327
United Kingdom	Nuclear material in facilities designated by the Agency	14 August 1978	263
United States of America	Nuclear material in facilities designated by the Agency	9 December 1980	288
(iv) Other agreements			
Argentina/Brazil		Signed: 13 December 1991	
Argentina/United States of America		25 July 1969	130
Austria[c]/United States of America		24 January 1970	152

* Amended in 1985 to cover specified nuclear facilities. The amendment entered into force on 8 November 1985 (INFCIRC/291/Mod.1/Corr.1).

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Brazil/Germany[c]		26 February 1976	237
Brazil/United States of America		31 October 1968	110
Colombia/United States of America		9 December 1970	144
India/Canada[c]		30 September 1971	211
India/United States of America		27 January 1971	154
Iran, Islamic Republic of[c]/ United States of America		20 August 1969	127
Israel/United States of America		4 April 1975	249
Japan[c]/Canada[c]		20 June 1966	85
Japan[c]/France		22 September 1972	171
Japan/United Kingdom		15 October 1968	125
Korea, Republic of/United States of America		5 January 1968	111
Korea, Republic of[c]/France		22 September 1975	233
Pakistan/Canada		17 October 1969	135
Pakistan/France		18 March 1976	239
Philippines[c]/United States of America		19 July 1968	120
Portugal[c]/United States of America[d]		19 July 1969	131
South Africa/United States of America		26 July 1967	98
South Africa/France		5 January 1977	244
Spain/Germany[c]		29 September 1982	305
Spain/United States of America		9 December 1966	92
Spain/Canada[c]		10 February 1977	247
Sweden[c]/United States of America		1 March 1972	165
Switzerland[c]/United States of America[d]		28 February 1972	161
Turkey[c]/United States of America[d]		5 June 1969	123
Venezuela[c]/United States of America[d]		27 March 1968	122

(v) The Agency also applies safeguards under two agreements (INFCIRC/133 and INFCIRC/158) to the nuclear facilities in Taiwan, China. Pursuant to the decision adopted by the Board of Governors on 9 December 1971 that the Government of the People's Republic of China is the only government which has the right to represent China in the Agency, the relations between the Agency and the authorities in Taiwan are non-governmental. The agreements are implemented by the Agency on that basis.

[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers.

[b] Agency safeguards are being applied to the items required to be safeguarded under this (these) project agreement(s) pursuant to an agreement in connection with NPT covering the State indicated.

[c] Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with NPT.

[d] Application of Agency safeguards under this agreement has been suspended in the United States of America in order to comply with a provision of INFCIRC/288.

Safeguards operations

Verification

Owing to budgetary constraints, the number of interim inspections needed for the purpose of flow verification in depleted, natural and low enriched uranium conversion and fuel fabrication plants was significantly reduced. Consequently, the inspection goals for the affected facilities were not attained.

Eight inspection missions were performed in order to verify the correctness and completeness of the State's initial inventory declarations in two cases where new comprehensive safeguards agreements entered into force. A near-simultaneous physical inventory verification was carried out in one State in August over a period of two weeks. Evaluation of the inspection results obtained indicates satisfactory confirmation of the operator's declaration. The task was still continuing at the end of 1992 in the case of the other State.

Two initial inspections were performed in one State to verify the receipt of equipment subject to safeguards under an INFCIRC/66/Rev.2 type agreement.

A dual containment/surveillance (C/S) system was installed at a CANDU type facility in one State. The initial transfer of spent fuel bundles to a dry storage covered by dual C/S measures was verified.

Initial preparations and tests were made for the forthcoming verification of spent fuel transfers to a dry storage at a CANDU type facility in another State.

A prototype fast breeder reactor received its first batch of fresh MOX fuel assemblies in July. The Agency applied C/S measures to cover the nuclear material transfer.

Design information verification activities were officially started for an experimental criticality facility in one State.

At a MOX fuel fabrication plant in one State new equipment was introduced to achieve improved verification of scrap material. At the same facility, reusable seals of the variable coding sealing system (VACOSS) type were installed. This will result in a reduction of the inspection effort and of the radiation exposure of inspectors and facility staff.

At another MOX fuel fabrication plant, improved software was installed to improve sample selection and streamline the activities of the inspectors.

A new non-destructive analysis (NDA) verification method, including authentication procedures for fuel in a closed shielded container, was tested and implemented by the Agency and EURATOM. A multicamera optical surveillance system (MOS) with an interface to a VACOSS system was tested.

A facility specific containment and surveillance system (known as the Consulha system) was tested in the field. This system, developed through a Member State support programme, comprises automated surveillance and measurement systems used for verifying receipts of spent fuel.

A shipment of plutonium was verified, using NDA measurement techniques, and sealed by the Agency prior to shipment from France to Japan. The verification results confirmed the operator's declaration. Arrangements were completed at the receiving facility for verification of the material upon receipt of this shipment.

Safeguards inspection verification activities

	1990	1991	1992
Inspections performed	2 188	2 145	2 047
Person-days of inspection	10 381	9 442	8 385
Seals applied to nuclear material or Agency safeguards equipment detached and subsequently verified (including seals applied jointly with a group of States)	26 600	24 300	21 100
Optical surveillance films reviewed	3 300	3 300	3 260
Video tapes reviewed	700	1 065	2 060
Plutonium and uranium samples analysed	1 510	1 090	1 439[a]
Analytical results reported	2 900	2 830	3 240

[a] Including 372 samples taken by the IAEA Action Team under Security Council Resolution 687.

Verification (cont.)

A new multicamera system was installed as part of dual containment and surveillance at a special nuclear storage facility. A field test for the sealing of multielement spent fuel storage containers was successfully completed at another large storage facility.

An enrichment facility in a nuclear-weapon State, previously involved in non-civil activities, was placed under safeguards for a period of five months and the physical inventory verification was completed. This facility may come under safeguards again in 1993.

As part of a programme to install modular integrated video system (MIVS) closed circuit television (CCTV) systems, replacing Minolta cameras, the installation of 141 such systems was completed at 70 facilities.

Negotiation of subsidiary arrangements

Owing to budgetary constraints, the negotiation of subsidiary arrangements and facility attachments proceeded more slowly than originally planned. However, the availability of extrabudgetary funds in the second half of the year made it possible for a negotiation team to travel to South Africa and to Algeria. It also enabled discussions to be held with representatives of Argentina, Brazil and the ABACC regarding the implementation of their comprehensive safeguards agreement with the Agency.

Most of the negotiation of facility attachments was carried out by correspondence. Some progress was achieved: three General Parts to Subsidiary Arrangements (one in 1991) and 36 (16 new and 20 revised) Facility Attachments (35 in 1991) entered into force:

- The General Part of the Subsidiary Arrangements with South Africa containing the strengthened requirements for the submission of design information entered into force in August. The Facility Attachments for the two power reactors and the research reactor entered into force in September. Significant progress was achieved in the negotiation of four other Facility Attachments.
- The General Part of the Subsidiary Arrangements with the Democratic People's Republic of Korea entered into force in July. The Facility Attachments for a research reactor, a critical assembly and a subcritical assembly entered into force in September. Negotiation of the remaining Facility Attachments continued.

Approximate quantities of material subject to Agency safeguards at the end of 1992

Type of material	Quantity of material (t)			
	INFCIRC/153[a]	INFCIRC/66[b]	Nuclear-weapon States	Quantity in SQs
Nuclear material				
Plutonium[c] contained in irradiated fuel	259.0	23.3	83.9	45 780
Separated plutonium outside reactor cores	10.9	0	24.4	4 424
Recycled plutonium in fuel elements in reactor cores	1.9	0.4	0	284
HEU (equal to or greater than 20% uranium-235)	10.5	0.4	0	251
LEU (less than 20% uranium-235)	26 699	1 983	7 151	9 959
Source material[d] (natural or depleted uranium and thorium)	51 597	3 526	22 835	5 180
Total significant quantities				65 878
Non-nuclear material[e]				
Heavy water	0	1 415	0	71

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

[c] The quantity includes an estimated 66.9 t (8360 SQ) of plutonium in irradiated fuel, which is not yet reported to the Agency under the reporting procedures agreed to (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and C/S measures are applied).

[d] This table does not include material within the terms of subparagraphs 34(a) and (b) of INFCIRC/153 (Corrected).

[e] Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2-type agreements.

Number of facilities under safeguards or containing safeguarded material on 31 December 1992

Facility category	Number of facilities (number of installations)			
	INFCIRC/153[a]	INFCIRC/66/ Rev. 2[b]	Nuclear-weapon States	Total
Power reactors	151 (182)	13 (17)	2 (2)	166 (201)
Research reactors and critical assemblies	134 (145)	22 (22)	2 (2)	158 (169)
Conversion plants	6 (7)	3 (3)	0 (0)	9 (10)
Fuel fabrication plants	33 (34)	9 (9)	1 (1)	43 (44)
Reprocessing plants	5 (5)	1 (1)	0 (0)	6 (6)
Enrichment plants	5 (5)	1 (1)	1 (1)	7 (7)
Separate storage facilities	35 (36)	6 (6)	5 (5)	46 (47)
Other facilities	54 (57)	4 (4)	0 (0)	58 (61)
Subtotals	423 (471)	59 (63)	11 (11)	493 (545)
Other locations	290 (468)	28 (32)	0 (0)	318 (500)
Non-nuclear installations	0 (0)	3 (3)	0 (0)	3 (3)
Totals	713 (939)	90 (98)	11 (11)	814 (1048)

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco; excludes locations in Iraq.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

Negotiation of subsidiary arrangements (cont.)

- The General Part of the Subsidiary Arrangements with Algeria covering a research reactor entered into force in July. The General Part of the Subsidiary Arrangements covering a second research reactor and the related Facility Attachment were submitted to the State. Further negotiations were held in Algeria in October and significant progress was made in the completion of the three documents outstanding.
- The Subsidiary Arrangements with Pakistan covering a new miniature neutron source reactor were prepared. The inspection for design information and initial inventory verification was performed in December.

Special substitution arrangements were completed in one State to permit the manufacture of separated plutonium into MOX fuel. Proposals for additions and amendments to the relevant Subsidiary Arrangements were made to the State.

Special substitution arrangements were agreed with another State to permit the manufacture of CANDU fuel bundles. Detailed procedures and modifications to the Subsidiary Arrangements were prepared.

Following discussion by the Board of Governors regarding the early provision by States of facility design information, proposals were made to Member States for amending the relevant code of the Subsidiary Arrangements and a number of States have agreed to such amendments.

Liaison with State authorities

Committees and other regular forms of contact between the Agency and Member States, including working arrangements with facility operators were carried out at a reduced level. However, they continued to contribute to the further improvement of safeguards implementation.

Following the endorsement of the Partnership Approach by the CEC and the Agency, discussions were initiated to pursue the development of practical arrangements for its implementation. Arrangements for implementing this approach at 41 LWRs without MOX were agreed upon. The two organizations initiated a limited implementation of the approach for selected LWRs to acquire the necessary experience. Preliminary results were positive. When fully implemented, these arrangements on LWRs without MOX will result in a substantial reduction of inspection effort.

Nuclear material accountancy

The Board of Governors began consideration of the Secretariat's proposal for reporting on the export and import of nuclear material, and specified equipment and non-nuclear material. Pending further consideration of the proposal, the Board concluded that States might be willing to provide such information on a voluntary basis. An analysis of the information requirements was prepared and provided to all Member States. An analysis was also initiated to prepare the specifications for a computerized system to process such information.

Safeguards agreements concluded pursuant to INFCIRC/153 include provision for the Agency to exempt nuclear material from safeguards at the request of the State either on the basis of certain specified intended uses of the material or within certain prescribed quantities. Safeguards agreements concluded pursuant to INFCIRC/66/Rev.2 provide for the exemption of nuclear material at the request of the State, not to exceed certain quantities. Under certain agreements concluded pursuant to INFCIRC/66/Rev.2, heavy water may be excluded within specified quantities agreed between the Agency and the State concerned.

Total amounts of material exempted from safeguards during 1992

Type of material	INFCIRC/66		INFCIRC/153			
	Exemption by quantity		Exemption by quantity		Exemption by use	
	Number of States	Amount	Number of States	Amount	Number of States	Amount
Plutonium	0	0	0	0	1	1.50 g
Enriched uranium	0	0	1	0.01 g	1	18.10 g
Natural uranium	0	0	2	15 kg	2	4 kg
Depleted uranium	0	0	2	1 230 kg	7	20 144 kg
Thorium	0	0	0	0	3	50 kg
Heavy water	0	0	n/a	n/a	n/a	n/a

Training courses and seminars held

Course name	Location	No. of participants	Duration
Workshop on accounting and reporting	South Africa	22	5 days
Seminar on SSAC	Ukraine	30	5 days

Facilities under Agency safeguards or containing safeguarded material on 31 December 1992

Power reactors

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Argentina	Atucha NPS	1	Lima	x
	Embalse PR	1	Embalse	—
Belgium	BR3-Mol	1	Mol	x
	DOEL-1	2	Doel	x
	DOEL-3	1	Doel	x
	DOEL-4	1	Doel	x
	Tihange-1	1	Tihange	x
	Tihange-2	1	Tihange	x
	Tihange-3	1	Tihange	x
Brazil	Angra-1	1	Angra dos Reis	x
Bulgaria	Kozloduy-I	2	Kozloduy	x
	Kozloduy-II	2	Kozloduy	x
	Kozloduy-III	2	Kozloduy	x
Canada	Bruce A	4	Tiverton	x
	Bruce B	4	Tiverton	x
	Darlington N.G.S.	4	Bowmanville	x
	Gentilly-2	1	Gentilly	x
	Pickering G.S.	8	Pickering	x
	Point Lepreau G.S.	1	Point Lepreau	x
China	QSNPP	1	Hai Yan	—
Cuba	Juragua	3	Juragua	x
Czechoslovakia	Al	1	Bohunice	x
	EDU-1	2	Dukovany	x
	EDU-2	2	Dukovany	x
	EMO-1	2	Mochovce	—
	V-1	2	Bohunice	x
	V-2	2	Bohunice	x
Democratic People's Republic of Korea	Nyongbyon-1	1	Nyongbyon	—
Finland	Loviisa	2	Loviisa	x
	TVO-1	1	Olkiluoto	x
	TVO-2	1	Olkiluoto	x
Germany	AVR	1	Jülich	—
	KWG Grohnde	1	Grohnde	—
	GKN-2	1	Neckarwestheim	x
	RWE Biblis-A	1	Biblis	x
	RWE Biblis-B	1	Biblis	x
	KBR Brokdorf	1	Brokdorf	—
	KKB Brunsbüttel	1	Brunsbüttel	x
	KKE Emsland	1	Lingen	x
	KKG Grafenrheinfeld	1	Grafenrheinfeld	—
	KKI Isar-Ohu	1	Ohu bei Landshut	x
	KKI Isar-2	1	Essenbach	x
	KKK Krümmel	1	Geesthacht	x

Power reactors (cont.)

State*	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Germany (cont.)	RWE Mülheim-Kärlich	1	Mülheim-Kärlich	x
	GKN Neckarwestheim	1	Neckarwestheim	x
	KWO Obrigheim	1	Obrigheim	x
	KKP Philippsburg-1	1	Philippsburg	x
	KKP Philippsburg-2	1	Philippsburg	—
	KRB II Gundremmingen B	1	Gundremmingen	x
	KRB II Gundremmingen C	1	Gundremmingen	x
	KKS Stade	1	Stade	x
	KKU Unterweser	1	Unterweser	x
	KKW Würgassen	1	Würgassen	x
	KBG-KNK-II	1	Eggenstein-Leopoldshafen	x
	HKG-THTR 300	1	Hamm	—
	KKW Greifswald 1	2	Greifswald	—
	KKW Greifswald 2	2	Greifswald	—
	KKW Greifswald 3	1	Greifswald	—
	KKW Rheinsberg	1	Rheinsberg	—
Hungary	PAKS-I	2	Paks	x
	PAKS-II	2	Paks	x
India	RAPS	2	Rajasthan	x
	TAPS	2	Tarapur	x
Italy	ENEL-Latina	1	Borgo-Sabatino	x
	ENEL-Caorso	1	Caorso	x
	ENEL-Trino	1	Trino-Vercellese	x
Japan	Fugen	1	Tsuruga-Fukui	x
	Fukushima Dai-Ichi-1	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-2	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-3	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-4	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-5	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-6	1	Okuma-Fukushima	x
	Fukushima Dai-Ni-1	1	Naraha-Fukushima	x
	Fukushima Dai-Ni-2	1	Naraha-Fukushima	x
	Fukushima Dai-Ni-3	1	Naraha-Fukushima	x
	Fukushima Dai-Ni-4	1	Naraha-Fukushima	x
	Genkai-1	1	Kyushu	x
	Genkai-2	1	Kyushu	x
	Hamaoka-1	1	Hamaoka-cho	x
	Hamaoka-2	1	Hamaoka-cho	x
	Hamaoka-3	1	Hamaoka-cho	x
	Hamaoka-4	1	Hamaoka-cho	—
	Ikata-1	1	Nishiuwa-gun	x
	Ikata-2	1	Nishiuwa-gun	x
	Joyo	1	Higashi-gun	x
	Kashiwazaki-1	1	Niigata	x
	Kashiwazaki-2	1	Niigata	x
	Kashiwazaki-3	1	Niigata	—
	Kashiwazaki-5	1	Niigata	x
	Mihama-1	1	Mihama-Fukui	x
	Mihama-2	1	Mihama-Fukui	x
	Mihama-3	1	Mihama-Fukui	x

Power reactors (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan (cont.)	Monju	1	Tsuruga-Shi	x
	Ohi-1&2	2	Ohi-cho, Fukui-ken	x
	Ohi-3	1	Ohi-cho, Fukui-ken	x
	Ohi-4	1	Ohi-cho	x
	Onagawa-1	1	Miyaki-ken	x
	Sendai-1	1	Sendai	x
	Sendai-2	1	Sendai	x
	Shika	1	Hakui-gun	—
	Shimane-1	1	Kashima-cho	x
	Shimane-2	1	Kashima-cho	x
	Takahama-1	1	Takahama	x
	Takahama-2	1	Takahama	x
	Takahama-3	1	Takahama	x
	Takahama-4	1	Takahama	x
	Tokai-1	1	Tokai-Mura	x
	Tokai-2	1	Tokai-Mura	x
	Tomari-1	1	Tomari-Mura	x
	Tomari-2	1	Tomari-Mura	x
	Tsuruga-1	1	Tsuruga	x
	Tsuruga-2	1	Tsuruga	x
Korea, Republic of	Kori-1	1	Pusan	x
	Kori-2	1	Pusan	x
	Kori-3	1	Pusan	x
	Kori-4	1	Pusan	x
	Uljin-1	1	Uljin	x
	Uljin-2	1	Uljin	x
	Wolsung-1	1	Ulsan	x
	Yongwang 1	1	Pusan	x
	Yongwang 2	1	Pusan	x
Lithuania	Ignalina 1	1	Visaginas	—
	Ignalina 2	1	Visaginas	—
Mexico	Laguna Verde 1	1	Alto Lucero	x
Netherlands	Borssele	1	Borssele	x
	Dodewaard NPP	1	Dodewaard	x
Pakistan	KANUPP	1	Karachi	x
Philippines	PNPP-1	1	Morong, Bataan	x
Russian Federation	Novo Voronezh Unit 5	1	Novo Voronezh	x
Slovenia	Krško	1	Krško	x
South Africa	Koeberg-1	1	Cape Town	x
	Koeberg-2	1	Cape Town	x
Spain	Almaraz-1	1	Almaraz	—
	Almaraz-2	1	Almaraz	—
	Asco-1	1	Asco	—
	Asco-2	1	Asco	—
	Cofrentes	1	Cofrentes	—
	José Cabrera	1	Almonazid de Zorita	—
	Santa María de Garona	1	Santa María de Garona	—
	Trillo-1	1	Trillo	—

Power reactors (cont.)

State*	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Spain (cont.)	Vandellos 1	1	Vandellos	—
	Vandellos 2	1	Vandellos	—
Sweden	Barsebäck I	1	Malmö	x
	Barsebäck II	1	Malmö	x
	Forsmark I	1	Uppsala	x
	Forsmark II	1	Uppsala	x
	Forsmark III	1	Uppsala	x
	Oskarshamn I	1	Oskarshamn	x
	Oskarshamn II	1	Oskarshamn	x
	Oskarshamn III	1	Oskarshamn	x
	Ringhals I	1	Göteborg	x
	Ringhals II	1	Göteborg	x
	Ringhals III	1	Göteborg	x
	Ringhals IV	1	Göteborg	x
Switzerland	KKB Beznau I	1	Beznau	x
	KKB Beznau II	1	Beznau	x
	KKG Gösgen	1	Gösgen-Däniken	x
	KKL Leibstadt	1	Leibstadt	x
	KKM Mühleberg	1	Mühleberg	x

Research reactors and critical assemblies

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Algeria	NUR Reactor	1	Algiers	—
	Es Salam research reactor	1	Ain Oussera	—
Argentina	RA-1 (reactor argentino-1)	1	Constituyentes	x
	RA-2 (reactor argentino-2)	1	Constituyentes	x
	RA-3 (reactor argentino-3)	1	Ezeiza	x
	RA-4 (reactor argentino-4)	1	Rosario	x
	RA-6 (reactor argentino-6)	1	Bariloche	x
	RA-0 (reactor argentino-0)	1	Córdoba	—
Australia	HIFAR	1	Lucas Heights	x
	MOATA	1	Lucas Heights	x
	CF	1	Lucas Heights	x
Austria	ASTRA	1	Seibersdorf	x
	Siemens Argonaut Reactor (SAR)	1	Graz	x
	Triga II	1	Vienna	x
Bangladesh	Atomic Energy Research Est.	1	Ganakbari Savar Dhaka	x
Belgium	BR1-CEN	1	Mol	x
	BR2-CEN-BRO2	2	Mol	x
	CEN-Venus	1	Mol	x
	Thetis	1	Gent	x
Brazil	IEA-R1	1	São Paulo	x
	RIEN-1 Argonaut RR	1	Rio de Janeiro	x
	Triga-CDTN	1	Belo Horizonte	x
Bulgaria	IRT-2000	1	Sofia	x
Canada	McMaster	1	Hamilton	x
	NRU	1	Chalk River	x
	NRX	1	Chalk River	x
	Reactor&Physics	2	Chalk River	x
	Slowpoke-AECL	1	Ottawa	x
	Slowpoke-Dalhousie Univ.	1	Halifax	x
	Slowpoke-Ecole Polytechnique	1	Montreal	x
	Slowpoke-Kingston	1	Kingston	x
	Slowpoke-Saskatchewan	1	Saskatoon	x
	Slowpoke-Univ. of Toronto	1	Toronto	x
	Slowpoke-Univ. of Alberta	1	Edmonton	x
	WNRE	1	Pinawa	x
Chile	La Reina	1	Santiago	x
	Lo Aguirre	1	Santiago	x
China	HWRR	1	Beijing	—
Colombia	IAN-R1	1	Bogotá	—
Czechoslovakia	LR-O	1	Řež	x
	SR-OD	1	Vochov	x
	Univ. Training Reactor VR-1P	1	Prague	x
	VVR-S	1	Řež	x
Democratic People's Republic of Korea	Critical assembly	1	Nyongbyon	x
	IRT-DPRK	1	Nyongbyon	x

Research reactors and critical assemblies (cont.)

State*	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Denmark	DR-1	1	Roskilde	x
	DR-3	1	Roskilde	x
Egypt	RR-I	1	Inshas	x
Finland	Triga II	1	Otaniemi	x
Germany	BER-2	1	Berlin	x
	PTB	1	Braunschweig	x
	FRF-2	1	Frankfurt	x
	FRM	1	Garching	x
	GKSS-FRG1&FRG2	2	Geesthacht	x
	KFA-FRJ2	1	Jülich	x
	SUR 100	1	Bremen	x
	SUR 100	1	Eggenstein-Leopoldshafen	x
	SUR 100	1	Hannover	x
	SUR 100	1	Kiel	x
	SUR 100	1	Hamburg	x
	SUR 100	1	Ulm	x
	SUR 100	1	Stuttgart	x
	SUR 100	1	Furtwangen	x
	SUR 100	1	Darmstadt	x
	SUR 100	1	Berlin	x
	SUR 100	1	Aachen	x
	Tech. Univ. AKR	1	Dresden	x
	Tech. Hochschule ZLR	1	Zittau	—
	Triga	1	Mainz	x
	Triga	1	Hannover	x
	Triga II	1	Heidelberg	x
	ZFK RAKE&RRR	2	Rossendorf	x
	ZFK research reactor	1	Rossendorf	x
Greece	GRR-1	1	Attiki	x
Hungary	Training reactor	1	Budapest	x
	WWR-S M	1	Budapest	x
Indonesia	Gama	1	Yogyakarta	x
	MPR-30	1	Serpong	x
	PPTN	1	Bandung	x
Iran, Islamic Republic of	TRR	1	Tehran	x
	HWZPR	1	Esfahan	—
	MNSR	1	Esfahan	—
Israel	IRR-1	1	Soreq	x
Italy	AGN-201	1	Palermo	x
	CESNEF-L54	1	Milan	x
	RB-3	1	Montecuccolino	x
	RTS-1	1	San Piero a Grado	x
	TAPIRO	1	Santa Maria di Galeria	x
	Triga-RC1	1	Santa Maria di Galeria	x
	Triga-2	1	Pavia	x
Jamaica	Centre for Nuclear Sciences	1	Kingston	x

Research reactors and critical assemblies (cont.)

State*	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan	DCA	1	Oarai-Machi	x
	FCA	1	Tokai-Mura	x
	HTR	1	Kawasaki-shi	x
	JMTR	1	Oarai-Machi	x
	JMTR-CA	1	Oarai-Machi	x
	JRR-2	1	Tokai-Mura	x
	JRR-3	1	Tokai-Mura	x
	JRR-4	1	Tokai-Mura	x
	Kinki University R.R.	1	Kowake	x
	KUCA	3	Kumatori-cho	x
	KUR	1	Kumatori-cho	x
	Musashi College R.R.	1	Kawasaki	x
	N.S. Mutsu	1	Minato-Machi	x
	NCA	1	Kawasaki-ku	x
	NSRR	1	Tokai-Mura	x
	Nucef	1	Tokai-Mura	—
	Rikkyo University R.R.	1	Nagasaka	x
	TCA	1	Tokai-Mura	x
	TODAI	1	Tokai-Mura	x
	TTR	1	Kawasaki-shi	x
	VHTRC	1	Tokai-Mura	x
Korea, Republic of	Triga II&III	2	Seoul	x
	Kyung-Hee Univ.	1	Seoul	x
Libyan Arab Jamahiriya	IRT Reactor	1	Tajura	x
Malaysia	Puspati	1	Bangi, Selangor	x
Mexico	Triga Mark III	1	Ocoyoacac	x
Netherlands	HOR	1	Delft	x
	HFR	1	Petten	x
	LFR	1	Petten	x
Norway	HBWR-Halden	1	Halden	x
	JEEP-II	1	Kjeller	x
Pakistan	PARR-1	1	Rawalpindi	x
	PARR-2	1	Rawalpindi	—
Peru	Centro nucl. de investigaciones	1	San Borja	x
	RP-10	1	Lima	x
Philippines	PRR-1	1	Diliman, Quezon City	x
Poland	Agata&Anna	2	Świerk	x
	Ewa	1	Świerk	x
	Maria	1	Świerk	x
Portugal	RPI	1	Sacavem	x
Romania	Triga II	1	Piteşti Colibaşi	x
	VVR-S	2	Magurele	x
Russian Federation	IR-8 research reactor	1	Moscow	x
Slovenia	Triga II	1	Ljubljana	x
South Africa	SAFARI-1	1	Pelindaba	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Spain	ARBI	1	Bilbao	—
	ARGOS	1	Barcelona	—
	JEN-1 and JEN-2	1	Madrid	—
Sweden	R2&R2-O	2	Studsvik	x
Switzerland	AGN 211P	1	Basel	x
	Crocus	1	Lausanne	x
	Proteus	1	Würenlingen	x
	Saphir	1	Würenlingen	x
Thailand	TRR-1	1	Bangkok	x
Turkey	Cekmece Nuclear Research Training Centre	1	Istanbul	x
	ITU-TRR Triga Mark II	1	Istanbul	x
Uruguay	Centro Investigaciones Nucleares	1	Montevideo	x
Venezuela	RV-1	1	Altos de Pipe	x
Viet Nam	Da Lat Research Reactor	1	Da Lat	x
Yugoslavia	RA-RB	2	Vinča	x
Zaire	Zaire Triga II	1	Kinshasa	x

Conversion plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	UO_2 Conversion Plant	Córdoba	—
	Uranium Powders Fabrication Plant	Constituyentes	—
Canada	CAMECO	Port Hope	x
Japan	Japan Nuclear Fuel Conversion Co. Ltd.	Tokai-Mura	x
	Ningyo R & D	Ningyo	x
	PCDF	Tokai-Mura	x
Romania	UO_2 powder fabrication plant	Feldioara	—
South Africa	Conversion plant	Pelindaba	—

Fuel fabrication plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Atucha Fuel Fabrication Plant	Ezeiza	—
	Fuel Fabrication Plant (CANDU)	Ezeiza	—
	Pilot Fuel Fabrication Plant (HEU)	Constituyentes	x
	Research Reactor Fuel Fab. Plant	Constituyentes	—
Belgium	BN-MOX	Dessel	x
	FBFC	Dessel	x
	FBFC MOX Assembling Facility	Dessel	—
Brazil	Fuel Fabrication Plant Resende	Resende	x
Canada	CRNL Fuel Fabrication	Chalk River	x
	Fuel fabrication facility	Chalk River	x
	GEC pelletizing facility	Toronto	x
	General Electric FFP	Peterborough	x
	Zircatec P.I. Ltd	Port Hope	x
Democratic People's Republic of Korea	Fuel fabrication plant	Nyongbyon	—
Denmark	Metallurgy	Roskilde	x
Germany	Adv. Nuclear Fuels	Lingen	x
	NUKEM	Wolfgang	x
	Siemens Uran (two units)	Hanau	x
	Siemens MOX	Hanau	x
India	Ceramic fuel fab. assembly area	Hyderabad	x
	EFFP-NFC	Hyderabad	x
Indonesia	Experimental Fuel Element Installation (IEBE)	Serpong	x
	Research Reactor Fuel Element Production Installation (IPEBRR)	Serpong	x
Italy	Fabnuc	Bosco Marengo	x
Japan	JNF	Yokosuka	x
	MNF	Tokai-Mura	x
	NFI (Kumatori-1)	Kumatori, Osaka	x
	NFI (Kumatori-2)	Kumatori, Osaka	x
	NFI (Tokai) fuel fabrication	Tokai-Mura	x
	PFPF	Tokai-Mura	x
	PPFF	Tokai-Mura	x
Korea, Republic of	CANDU fuel fabrication	Daejeon	x
	KNFFP	Daejeon	x
Mexico	Fuel fabrication pilot plant	Ocoayacac	x
Romania	Romfuel	Piteşti Colibaşi	x
South Africa	MTR fuel fabrication	Pelindaba	—
	LEU fuel fabrication	Pelindaba	—
Spain	CIEMAT Planta Metall.	Madrid	—
	ENUSA Fuel Fabrication Plant	Juzbado	—
Sweden	ASEA-ATOM	Västeras	x
United States of America	Babcock & Wilcox Co.	Lynchburg, VA	x

Chemical reprocessing plants, including pilot plants

State*	Abbreviated name of facility	Location	Subsidiary arrangements in force
Democratic People's Republic of Korea	Radiochemical laboratory	Nyongbyon	—
Germany	WAK	Eggenstein-Leopoldshafen	x
India	PREFRE	Tarapur	x
Italy	EUREX	Saluggia	x
	ITREC-Trisaia	Rotondella	x
Japan	Tokai reprocessing plant	Tokai-Mura	x

Enrichment plants, including pilot plants

State*	Abbreviated name of facility	Location	Subsidiary arrangements in force
Brazil	Sep. Noz. enrichment plant	Resende	x
Germany	URENCO Deutschland, UTA-1	Gronau	x
Japan	Uranium enrichment plant	Ningyo	x
	Rokkosho enrichment plant	Rokkosho-Mura	x
Netherlands	URENCO Nederland	Almelo	x
South Africa	Semi-commercial enrichment plant	Pelindaba	—
United Kingdom	BNFL centrifuge plant and associated storage	Capenhurst	x

Separate storage facilities

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Central store	Ezeiza	—
	Storage of depleted hexafluoride	Bariloche	—
	Storage of zircaloy tubes	Ezeiza	—
	Storage of 20% enriched uranium	Constituyentes	—
Belgium	Belgoprocess	Mol	x
	BN UF_6 store	Dessel	x
Bulgaria	Long term storage	Kozloduy	—
Canada	CRNL	Chalk River	x
	CRNL spent fuel dry store	Chalk River	x
	Douglas Point	Tiverton	x
	Gentilly-1	Gentilly	x
	Long term storage at CRNL	Chalk River	x
Chile	Lab. experimental de conversión	Santiago	x
Czechoslovakia	AFRS	Bohunice	x
Democratic People's Republic of Korea	Nuclear fuel storage	Bungang-Ri	—
Denmark	Risø Store	Roskilde	x
	Risø Waste	Roskilde	—
Finland	Long term storage for spent fuel TVO	Olkiluoto	—
France	COGEMA UP2 spent fuel storage ponds	La Hague	x
Germany	Bundeslager	Wolfgang	—
	Exxon Nuclear UF6 Lageranlage	Lingen	x
	KFA Jülich Lager (AVR Kugeln)	Jülich	x
	KFK-FR-2	Eggenstein-Leopoldshafen	x
	BZA-Ahaus	Ahaus	—
	LSG Offset-Lager	Hanau	—
	Nuclear Cargo & Services	Hanau	—
	Urananlage	Birkenfeld	x
	VEB Greifswald	Greifswald	—
Hungary	Central radionuclide store	Budapest	x
Italy	Avogadro	Saluggia	x
	Deposito Prodotti Uraniferi	Bosco Marengo	x
	Essor Nuclear Plant	Ispra	—
	Essor Storage Pond	Ispra	—
	Ispra Central Storage	Ispra	x
	Joint Research Centre	Ispra	—
Japan	KUFFS	Kyoto	x
Luxembourg	International Metals S.A.	Luxembourg-Dommeldange	x
Pakistan	Government depot at Malir	Karachi Malir	x
Portugal	Instalação de Armazenagem	Sacavem	x
Russian Federation	Mashinostroitel'nyi Zavod	Ehlektrostal	—
South Africa	Waste Storage	Pelindaba	—
Sweden	Central long term storage	Oskarshamn	x
Switzerland	Diorit Storage	Würenlingen	x
United Kingdom	Oxide Fuel Storage Pond	Sellafield	x
	Sellafield Pu-storage	Sellafield	x
	Special nuclear material store 9	Sellafield	x

Other facilities

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Lab. de Calificación	Constituyentes	—
	Lab. triple altura	Ezeiza	—
Australia	Research Laboratory	Lucas Heights	x
Belgium	BCMN	Geel	x
	CEN-Labo	Mol	x
	CEN-Waste	Mol	—
	I.R.E.	Fleurus	x
	Pu laboratory	Mol	x
Cuba	Zero-power nuclear reactor	Havana	—
Czechoslovakia	Nuclear Fuel Inst. (UJP)	Zbraslav	x
	Research Laboratories	Řež	x
Democratic People's Republic of Korea	Subcritical assembly	Pyongyang	x
Denmark	Hotcell Plant	Roskilde	x
Germany	Deutsches Elektronen-Synchrotron	Hamburg	—
	KFA-heisse Zellen	Jülich	x
	KFK-heisse Zellen	Eggenstein-Leopoldshafen	x
	KFK/IHCH	Eggenstein-Leopoldshafen	x
	Siemens heisse Zellen	Karlstein	x
	Lab. d. KFA Jülich	Jülich	x
	Transuran	Eggenstein-Leopoldshafen	x
	VKT.UT + LAB	Rossendorf	x
	VKT. Tec. ZTR	Rossendorf	—
Iran, Islamic Republic of	LWSCR	Esfahan	—
	GSCR	Esfahan	—
Italy	CNEN-LAB. PU.	Santa Maria di Galeria	x
	CNEN-LAB. TEC.	Santa Maria di Galeria	x
Japan	JAERI-Oarai R&D	Oarai-Machi	x
	JAERI-Tokai R&D	Tokai-Mura	x
	Mitsui Iwakuni-Ohtake	Yamaguchi	—
	Mitsui Toatsu	Takai-shi	—
	NDC Fuel Hot Lab.	Tokai-Mura	x
	NDC fuel laboratories	Tokai-Mura	x
	NERL, University of Tokyo	Tokai-Mura	x
	NFD	Oarai-Machi	x
	NFI Tokai II	Tokai-Mura	x
	NRF Neutron Radiation Facility	Tsukuba	x
	PNC FMF	Oarai-Machi	x
	PNC IRAF	Oarai-Machi	x
	PNC-Oarai R&D	Oarai-Machi	x
	PNC-Tokai R&D	Tokai-Mura	x
	Showa	Kawasaki-shi	—
	Sumitomo-Chiba	Sodegaura-shi	—
	Uranium material laboratory	Oarai-Machi	x
Korea, Republic of	PIEF	Daejeon	x

Other facilities (cont.)

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Netherlands	ECN & JRC	Petten	x
	KEMA Lab.	Arnhem	x
Norway	Research laboratories	Kjeller	x
Poland	Institute for nuclear chemistry and engineering	Warsaw	—
	Institute of Nuclear Research	Świerk	x
South Africa	Decommissioned pilot enrichment plant	Pelindaba	—
	Decontamination and waste recovery	Pelindaba	—
	Hot Cell Complex	Pelindaba	—
	NU and DU metals plant	Pelindaba	—
Spain	CIEMAT Lab-Pu	Madrid	—
Sweden	Central storage fresh fuel	Studsvik	x
Switzerland	Fed. Inst. of Reactor Research	Würenlingen	x
Turkey	Nuclear fuel pilot plant	Istanbul	—

Non-nuclear installations

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Heavy water plant	Arroyito	—
	Heavy water storage	Buenos Aires	x
Cuba	Storage of equipment (VCIP)	Prov. Havana	—

[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

Note: The Agency was also applying safeguards in Taiwan, China, at six power reactors, six research reactors/critical assemblies, one uranium pilot conversion plant, two fuel fabrication plants and one research and development facility.

Locations in Iraq under the responsibility of the IAEA Action Team under Security Council Resolution 687

Reactor pond	Al Tuwaitha research centre
Location B	In the vicinity of Al Tuwaitha
Location C	In the vicinity of Al Tuwaitha

Safeguards support and development

Instrumentation development and field support

The extrabudgetary Member State support programmes continued to provide major contributions to the R&D and safeguards implementation support activities. Some two hundred projects were under way, addressing safeguards needs identified by the Agency. During the year bilateral meetings were held to review the status and activities of every programme. Procedures were introduced to ensure improved feedback on the use the Agency makes of the results of tasks completed under support programmes.

A new programme for co-ordinating longer term safeguards instrumentation initiatives to be carried out with the assistance of Member States and Member State support programmes was formulated and adopted.

Under the optical surveillance data reduction programme, two optical surveillance tape generic review stations (GRSs) were specified, designed and built through the assistance of two Member State support programmes and evaluated by an Agency team. The objective of the GRS is to reduce substantially the amount of time necessary to review optical surveillance data. In addition, the single unit is able to process a variety of video and tape formats, thus reducing the equipment inventory and the training requirements. The systems that were tested combine cost effective computer control and image processing. It is planned to have production model GRS systems available in 1993.

The testing of the COSMOS (compact surveillance and monitoring system) self-contained CCTV system was largely completed. It is expected that the COSMOS will be authorized for inspection use in 1993.

A 16-position multiplex CCTV system (MUX) was developed and successfully tested. Both the number of cameras and the tape recording capacity were increased by a factor of 2 over the presently authorized MUX system.

Additional support provided by States

States and organizations representing groups of States having formal support programmes	States having R&D contracts and test programmes
Australia Belgium Canada European Atomic Energy Community Finland France Germany Hungary Indonesia Japan Russian Federation (former USSR programme) Sweden United Kingdom United States of America	Argentina Austria Bulgaria Czechoslovakia Hungary Latvia Pakistan Yugoslavia

Instrumentation development and field support (cont.)

Radiation monitoring systems were designed for two fast breeder reactor facilities in one State and were installed. Similar systems for a research reactor in another State were designed and built. These systems will enable radiation surveillance to be implemented in difficult-to-access areas at these on-load facilities.

With the assistance of three Member State support programmes, authentication systems were designed, installed and tested in two separate facilities. Both systems are designed to assist inspectors to determine independently the correctness of data from two major in situ monitoring systems.

Instrumentation for facilities in three States for irradiated CANDU bundle verification were developed. Work began on installing and commissioning these systems. Their function will be to verify irradiated CANDU bundles prior to dry storage canister loading and to reverify bundles in the event of loss of continuity of knowledge and in the event of interbay transfers.

Seven items of Agency equipment were authorized for inspection use during 1992: the underwater neutron coincidence counter, the facility specific advanced containment and surveillance system, the CANDU bundle verifier for baskets, the tamper resistant TV link, the high count rate plutonium isotopic measurement station, the plutonium scrap multiplicity counter and the Consulha input flow verification system.

Substantial progress was made in improving the safeguards equipment management system, to make it capable of integrating a comprehensive range of data.

The deployment of a MIVS performance monitoring database made possible the evaluation of the performance statistics of these surveillance systems, covering preventive maintenance, reactive maintenance and replacement. Development of performance monitoring databases for other instrument types was initiated.

A workshop was held to discuss the shortcomings of the MIVS systems. As a first result, certain modifications to the MIVS systems and some procedural changes in quality control, testing, shipping and installation were initiated. The process of replacing all modules in the field continued, and should be completed in 1993.

During 1992 an additional 27 MIVS systems, as well as three multicamera optical surveillance systems and two MUX systems, were installed in facilities. Sixteen spent fuel bundle counters were upgraded with non-interruptible power supplies. A total of 386 MIVS modules were upgraded.

The Safeguards Analytical Laboratory (SAL) and the Network of Analytical Laboratories (NWAL) performed 4619 measurements for calibration and quality control of NDA techniques, for certification of secondary reference samples, for maintenance and improvement of off-site destructive analysis (DA) and for testing procedures for on-site DA. In addition, 2717 measurements were performed by SAL and the NWAL for the routine quality control of the analyses of inspection samples. SAL also assisted in the measurement of samples taken in Iraq during inspections carried out pursuant to Security Council Resolution 687, and performed 614 such measurements. A total of 282 analytical results were reported by SAL on environmental type samples.

The median times required to complete verification by off-site DA were 60 days for uranium, 67 days for plutonium and 76 days for spent fuel samples.

Instrumentation development and field support (cont.)

With the assistance of Member State support programmes and the NWAL, the following major development activities were accomplished or pursued:

- Tests were performed to set up a procedure for the determination of plutonium in milligram size mixed oxide samples.
- Following the work done in 1991, a demonstration system for decontamination of alpha bearing analytical discards was set up.
- The automatic potentiometric titration method for routine analysis of milligram size plutonium samples and the robotized chemical treatment procedure for diluted spent fuel samples submitted to the isotope dilution mass spectrometric method were validated and placed in routine use.
- The computerized interpretation of alpha spectra for measurement of plutonium isotopic composition in plutonium product and mixed oxide samples was further improved.
- Tests were carried out on the 'total evaporation' technique for thermal ionization mass spectrometry of uranium and plutonium with improved precision and accuracy.
- A quality assurance plan for SAL, based on accepted norms and statistical procedures, was completed.
- The design and specification for a high sensitivity mass spectrometer and clean room facility for high accuracy measurements of small samples were completed.

Equipment related activities

	1991	1992
Twin and triple photo units in use	225	225
Photo cameras repaired and tested	134	219
Photo unit failures related to equipment	0.5%	1.2%
Single camera video systems (MIVS):		
— MIVS in use	115	141
— MIVS failures related to equipment	31	43
— Mean time between failure	30 months	34.5 months
Multiple camera video systems:		
— MUX in use	—	11
— MUX failures related to equipment	—	None
— MOS in use	—	3
— MOS failures related to equipment	—	None
Metallic cap seals issued	17 107	12 600
Metallic cap seals verified	14 040	12 334
Shipments of equipment and supplies	366	311
Hand carried transport of equipment and supplies	394	306
Shipments of nuclear material and chemicals to facilities	118	137
Shipment of inspection samples, radioactive material standards and contaminated items to SAL	201	210
Procurement actions	1 205	1 350

Development of a safeguards system for a large reprocessing plant in Japan

Work continued on the preparation for safeguards implementation at a new major commercial reprocessing plant. In accordance with the project plan, a study was started of the safeguards aspects of spent fuel storage and continuous dissolution head-end systems. The development of the safeguards approach will take into consideration the findings of LASCAR. Extensive efforts were made to define the analytical requirements for an Agency on-site laboratory at the plant.

Development of a safeguards system for a heavy water production plant in Argentina (Arroyito)

The project to apply safeguards to the heavy water production plant at Arroyito was suspended in 1991 in the light of the new, comprehensive safeguards agreement concluded with Argentina, Brazil and the ABACC. However, because this agreement has yet to be ratified, the Agency has continued to review the design information of the plant. An equipment inspection with a site visit were carried out in November. A proposal for verification of design information and an interim inspection regime after startup in 1993 were prepared.

Development of a safeguards system for a multi-unit on-load reactor in Canada (Darlington)

Core discharge monitors (CDMs) were installed in all four of the Darlington units. The CDMs functioned properly throughout the year and routinely detected and recorded fuel discharges of very low burnup and long cooled bundles.

The use of the CDMs as sensitive radiation monitors resulted in a substantial saving in inspector resources. A final operational check is being made of the software and the system before the CDM is authorized for routine inspection use.

In order to improve in the near term the attainment of safeguards goals regarding core fuel at other multi-unit on-load refuelled reactors, an investigation of alternative safeguards approaches as a temporary measure continued. Detailed requirements for the possible implementation of a safeguards approach which makes use of the unique identification numbers inscribed on each CANDU fuel bundle were discussed with facility operators.

Development of a safeguards system for Siemens MOX fuel fabrication facility in Germany

The safeguards approach developed by the Agency was accepted in draft by the plant operator and EURATOM. A design information verification plan was developed by the Agency. The contract for procurement of the safeguards systems was negotiated and signed by the Agency, EURATOM and the plant operator. Procurement, installation and testing of equipment has not been completed owing to delays in the construction schedule of the facility. With the assistance of a Member State support programme, work began on the development of a software package for unattended in-line measuring equipment.

With the assistance of Member State support programmes, testing of a procedure based on random inspections for verification of nuclear material flow was initiated.

Development of a safeguards system for the CANDU-600 nuclear power complex in Romania (Cernavoda) and for RBMK reactors

A project team was established to develop and implement a safeguards scheme and approach at the first reactor unit of the Cernavoda CANDU type nuclear power plant in Romania.

Following the entry into force of the safeguards agreement pursuant to the NPT between Lithuania and the Agency, a safeguards approach for the RBMK-type reactors in Lithuania was established and initial preparations were made for the installation of surveillance systems.

Data processing development and services

A computer system was developed and put into production to generate the statement providing inspection results to the State on the basis of data in the computerized inspection report (CIR).

Steps were initiated to develop computer systems to store and retrieve safeguards related information collected from open sources (public media and scientific literature). These efforts are intended to provide early indications of nuclear related activities in a State which might seem to be inconsistent with the State's undertakings.

Steps were also taken to develop the necessary computer systems to process the voluntary submission of information by Member States on the export and import of nuclear material, specified equipment and non-nuclear material as proposed by the Director General to the Board of Governors.

Some enhancements were made to the data transmission procedures which connect the Toronto Regional Office to Headquarters.

System studies and approaches

Guidelines and procedures were developed to handle information related to nuclear activities in each State. More systematic collection and analysis of information on safeguards related issues in each State was initiated using information from open sources and from safeguards implementation. Guidelines were developed to assist staff in carrying out the required data analysis.

In consultation with Member States, the Agency continued a programme to develop safeguards requirements and methodologies for final geological spent fuel repositories and to formulate safeguards policy well before such facilities become operational. A comprehensive set of studies was proposed to Member State support programmes.

In support of activities of the Standing Advisory Group on Safeguards Implementation (SAGSI), a study of the radiation levels of power and research reactor spent fuel was undertaken. On the basis of this study, SAGSI advised on the parameters to be used in defining 'irradiated fuel' for safeguards purposes.

Following a SAGSI request, a study was undertaken of different schemes for applying the principle of randomization to timeliness inspections at LWRs.

Following established procedure, the 1993–1994 R&D programme was revised and updated, taking into consideration proposals for strengthening the safeguards system and for improving its cost effectiveness.

An internal technical analysis task force was established to develop an action plan for incorporating safeguards strengthening measures into inspection practice. This action plan includes further study of possible new concepts and approaches.

Standardization

A total of 2112 inspection reports (2230 in 1991) and 2387 inspection statements (2506 in 1991) were reviewed and computerized quality control checks applied.

Reports on the quality and timeliness of inspection documentation packages were made routinely. The average time between an inspection and the dispatch of results to the State was 58 days (61 days in 1991).

The testing of the seals verification activity continued. Within this programme, deliberately altered seals were submitted as a blind test of the verification

Standardization (cont.)

capability. The optical surveillance application review activity continued. A predetermined number of inspection reports were randomly selected and in-depth reviews conducted on the documentation on surveillance application.

Statistical analysis

Steps to implement major revisions in inspection sample size, error estimation and material balance methodologies, with particular emphasis on training and documentation, continued throughout the year. A project to update analytical error target values for both DA and NDA methods was completed. During 1992, 347 routine data evaluation reports were prepared, comprising material balance evaluations (137), operator–inspector pair evaluations (130) and verification performance history analyses (80).

Substantial effort was devoted to organizing and analysing the large quantities of sample data deriving from inspection activities in Iraq pursuant to Security Council Resolution 687.

Safeguards training

Thirty-five training courses were conducted at Headquarters and in Member States. Twenty-three courses provided basic, advanced, refresher and special training for staff, primarily inspectors; 12 other courses provided staff members with new and/or advanced skills applicable to data processing, management and other safeguards support areas. Individualized refresher training was given on C/S and NDA instrumentation.

In support of the Consulha surveillance project, a training programme was established. This included both self-paced video aided training and trainer administered performance checks to confirm trainees' ability to carry out the tasks required.

A departmental seminar on C/S technology was organized, consisting of presentations, poster sessions and discussions. Representatives of eight Member States presented current and future approaches to C/S technology.

Safeguards management

Planning, direction, co-ordination and control

Two regular meetings and two working group meetings were held by SAGSI. As its major activity, SAGSI continued its critical study of new and improved safeguards procedures. It began to re-examine safeguards implementation and to advise on ways to reduce costs while meeting new requirements and maintaining effectiveness. This re-examination will address improving cost effectiveness through the use of new techniques, through procedures to detect undeclared facilities, through increased co-operation with State systems of accounting and control of nuclear materials, and through the use of alternative safeguards approaches. For these purposes, the Director General temporarily appointed six additional members to SAGSI. In 1992, SAGSI discussed and made recommendations on new procedures to verify spent fuel at LWRs, possible applications of randomized inspections, and delays encountered in seeking to conclude the negotiation of facility attachments.

Effectiveness evaluation

The evaluation of inspection goal attainment for 1992 was made according to the safeguards criteria previously communicated to Member States, even though some of these criteria could not be completely implemented, partly as a result of financial restrictions. The evaluations were made as soon as possible after the end of the material balance period. This ensured, barring exceptional circumstances, conformity between the results reported to States under the terms of their agreements and the evaluation results. The evaluation results were reported to the Board of Governors in the Safeguards Implementation Report (SIR).

DIRECTION AND SUPPORT

Administration

Regular Budget

The General Conference appropriated an amount of $202 014 000 for the Agency's Regular Budget on the basis of an exchange rate of 10.90 Austrian Schillings to one United States dollar. This amount was adjusted to $201 196 000 in accordance with the adjustment formula presented in the attachment to Resolution GC(XXXV)/RES/556 in order to account for the average exchange rate of 10.95 Austrian Schillings to one US dollar which was actually experienced during the year. However, because of a shortfall in expected receipts, steps were taken to reduce the budget by 13% to $179 865 400.

The Regular Budget for 1992, at an exchange rate of 10.95 Austrian Schillings to one US dollar, amounted to $206 217 000, of which $197 656 000 was to be financed from contributions by Member States on the basis of the 1992 scale of assessment, $5 021 000 from income from reimbursable work for others and $3 540 000 from other miscellaneous income.

Expenditures

The actual expenditures for the Regular Budget in 1992 amounted to $178 659 358. In addition, the authority to spend an amount of $16 229 600 was reserved for Deferred Programme Activities to be carried out in 1993 if arrears of contributions would be received in time. Together with the actual expenditures this resulted in an unused budget of $11 328 042.

In 1992, expenditures for the 1991 Deferred Programme Activities amounted to $5 999 011 from a total of $7 796 936 carried forward at 31 December 1991.

Voluntary contributions

The target for voluntary contributions to the Technical Assistance and Co-operation Fund in 1992 was established at $52.5 million, of which $37.6 million was pledged by Member States.

Extrabudgetary contributions

A total of $19 994 400 was offered in extrabudgetary contributions by Member States, the United Nations and other international organizations during 1992. Of this amount, $6 550 201 was in support of safeguards, $3 388 472 was for technical assistance projects, $3 204 703 for projects in the field of food and agriculture, $2 747 967 for nuclear safety and $1 627 000 for the implementation of United Nations Security Council Resolution 687 on Iraq. The remaining $2 476 057 was in support of various other projects implemented by the Agency.

In addition, extrabudgetary resources amounting to $20 411 436 (supplemented by the Agency's contribution of $1 268 381) were donated for the ICTP and $1 237 633 (supplemented by the Agency's contribution of $2 129 801) for the IAEA-MEL.

Trust funds

In 1992, a total of $1 067 976 was provided by Member States for technical assistance and co-operation activities. Furthermore, a total of $1 023 883 was administered on behalf of research institutions.

Personnel

At the end of 1992, the number of members of the Secretariat was 2135 — 798 in the Professional and higher categories and 1337 in the General Service category. These figures represent: regular staff (1643), temporary assistance staff (115), extrabudgetary (281), cost free experts (72), consultants (23) and staff on loan to other organizations (1).

Among the 596 staff members in posts subject to geographical distribution, 80 nationalities were represented.

Recruitment of Professional staff in posts subject to geographical distribution continues to be monitored to ensure compliance with General Conference Resolution GC(XXV)/RES/386 regarding staff representation from developing countries. During the regular session of the General Conference a new resolution (GC(XXXVI)/RES/599) was adopted calling for improvement in the representation of women in the Secretariat.

At the end of 1992, measures taken to counter the Secretariat's financial situation had resulted in an increase in the Professional post vacancy rate to 13.2%, a 20% decrease in Professional and General Service temporary assistance staff and an increase of approximately 17% in fully cost free experts.

Staff representing developing countries remained at the same level of representation (approximately 28%) as at the end of 1991, even though a higher vacancy rate was maintained. The reduced recruitment activity for Professional posts hindered efforts to improve the representation of women in the Agency and by the end of the year the percentage of women in Professional posts was 13.7. In late 1992, measures were undertaken in accordance with Resolution GC(XXXVI)/RES/599 to further improve the representation of women in the Agency during 1993.

Management services

A total of ten management and efficiency reviews were completed during the year, the purpose being to review the work-load and staffing requirements of various sectors.

Liability for nuclear damage

The Standing Committee on Liability for Nuclear Damage held two more sessions during which consideration of all questions in its mandate was continued. Further progress was made on the revision of the Vienna Convention by substantially reducing the number of alternative proposals and adopting provisionally, as a basis for further consideration, the texts of draft amendments on all issues where a need for improvement was recognized. The Committee had before it alternative proposals on supplementary funding as set out in draft instruments. As the proposed systems had similarity in some basic aspects, a suggestion was considered that a common solution be reached by inclusion of certain key elements of one proposal into the other. Differences of principle remained on the proposals relating to international State liability and its relationship with a civil liability regime which were considered in the context of revision of the Vienna Convention.

There was wide support in the Committee for the view that, in the light of the results achieved, efforts at this stage should be concentrated on the revision of the Vienna Convention and supplementary funding where good prospects for further progress existed, and that those issues should continue to be considered in conjunction with each other. In order to facilitate the negotiating process, the Agency co-sponsored with the OECD/NEA a symposium on "Nuclear Accidents — Liabilities and Guarantees" in Helsinki, Finland. This provided a forum for intersessional consultations.

Liability for nuclear damage (cont.)

At meetings in June, the Board considered the question of liability for nuclear damage. Acting upon its report, the General Conference adopted Resolution GC(XXXVI)/RES/585 in which it referred to the priority it attached to the consideration of all aspects of nuclear liability and expressed the hope that the Standing Committee would complete its preparatory work soon, so that a revision conference on the Vienna Convention may then be convened.

International convention on nuclear safety

In the light of a report by the Director General on the work of the expert group set up in 1991 to advise on elements of a nuclear safety convention, the Board of Governors, at its February 1992 session, authorized the Director General to convene an open ended group of legal and technical experts with the task of carrying out the necessary substantive preparations for a nuclear safety convention. The group met in May and October. About ninety experts from 45 countries, the CEC, OECD/NEA and ILO participated.

The experts made progress in their task and agreed that: (a) the main obligations of the parties to the convention would be based in large measure on the principles for the regulation and management of safety and the operation of nuclear installations contained in an Agency Safety Fundamentals report entitled "The Safety of Nuclear Installations"; (b) the convention would provide for a binding obligation of the parties to report on the implementation of the convention, and for a review mechanism established through a 'Meeting of the Parties'; and (c) the Agency would provide this 'Meeting of the Parties' with support services, and technical and any other expertise as required.

The General Conference, at its regular session, adopted Resolution GC(XXXVI)/RES/582, which in paragraph 5

> "*Takes note* of the work done so far by the Group of Experts for the drafting of a nuclear safety convention and urges the Group to continue its work taking into account the comments made by Member States during this Conference and the vital necessity of a continuing effort to raise the general level of nuclear safety worldwide."

Physical protection

The Review Conference of the Convention on the Physical Protection of Nuclear Material was convened by the Agency in Vienna in September. It was attended by 35 of the 42 Parties to the Convention and by observers from 6 Member States and 2 international organizations.

The Conference unanimously adopted the final statement in which the Parties expressed their full support for the Convention. The Parties considered that the Convention provided a sound basis for the physical protection of nuclear material during international transport, as well as an appropriate framework for international co-operation in the protection, recovery and return of stolen nuclear material and in the application of criminal sanctions against persons who commit criminal acts involving nuclear material. They urged all States that have not yet done so to become party to the Convention.

The Parties recognized that INFCIRC/225/Rev.2, "The Physical Protection of Nuclear Material", provided useful guidance on the measures for the physical protection of nuclear material in use, transit and storage. The Conference also called upon the Agency to organize a meeting in the near future to examine INFCIRC/225/Rev.2, primarily to consider the need for consistency of the Categorization Table with the Convention and to consider the incorporation of further guidance on such issues as irradiated fuel, nuclear material contained in waste and other issues.

Status of conventions and agreements

On 28 April 1992, the Director General received a note from the Permanent Mission of the Federal Republic of Yugoslavia informing him that "the Federal Republic of Yugoslavia shall continue to fulfil all the rights conferred to and obligations assumed by the Socialist Federal Republic of Yugoslavia in international relations, including ... participation in international treaties ratified or acceded to by Yugoslavia."

During 1992, two States accepted the Agreement on the Privileges and Immunities of the IAEA (reproduced in document INFCIRC/9/Rev.1). The number of Member States who have accepted the Agreement is now 63.

The Vienna Convention on Civil Liability for Nuclear Damage, which entered into force on 12 November 1977, now has 17 Parties as a result of succession or accession by three States.

In 1992, two States notified the Agency of their succession to the Convention on the Physical Protection of Nuclear Material (reproduced in document INFCIRC/274/Rev.1), which entered into force on 8 February 1987. Thus, by the end of the year there were 42 Parties.

The Convention on Early Notification of a Nuclear Accident (reproduced in document INFCIRC/335), which entered into force on 27 October 1986, was acceded to by one State and two States notified their succession. By the end of the year there were 64 Parties.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in document INFCIRC/336), which entered into force on 26 February 1987, was ratified or acceded to by two States and succession by two States was notified. There were 62 Parties by the end of 1992.

The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (reproduced in document INFCIRC/402) entered into force on 27 April 1992. There are currently 10 States Parties to the Protocol.

The African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Energy (AFRA) (reproduced in document INFCIRC/377), which entered into force on 4 April 1990, was accepted by two States during 1992. By the end of the year 15 States had accepted the Agreement.

The Agreement to Extend the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology, 1987 (RCA) (reproduced in document INFCIRC/167/Add.15), entered into force on 11 June 1992. By the end of the year, 14 States had accepted the Agreement.

Technical co-operation servicing and co-ordination

General

The two year cycle in force for the Agency's technical co-operation activities since 1989 has made it possible to place greater emphasis on project preparation. This was noticeable during the formulation of the 1993–1994 biennial programme, which took place during the year under review. Many proposals were in line with recommendations made by preparatory assistance and country review missions. Through new projects and through consolidation with other requests or with already approved assistance, over 80% of the requests received were included in the programme.

Work was initiated in the latter half of the year to identify and develop future model projects which would be examples of end-user oriented activities with a direct impact on the community beyond the recipient institutes. These projects serve as indicators of the direction in which the technical co-operation programme would gradually move.

Resources and implementation

Total new resources available for technical co-operation suffered severely in 1992 from a sharp drop in the exchange rate of non-convertible currencies, so that the total value of new resources only reached $40.3 million, as against $49.1 million in 1991.

The Technical Assistance and Co-operation Fund (TACF) accounted for 82.9% of these resources, with extrabudgetary funds accounting for 12.4%, assistance in kind for 3.2% and UNDP for 1.5%. The exchange losses incurred in the non-convertible currency portion of the TACF caused a further decline in the percentage of the target met through pledges, to 71.6%. However, it should be noted that with respect to convertible currencies, contributions rose by 8.6%, or nearly $3 million, so that in this portion of the TACF the percentage of the target met through pledges increased from 80% in 1991 to 81.1% in 1992.

Extrabudgetary contributions were affected by a reduction in the volume of contributions by some traditional large donors, and were at $5 million, 29% below the level reached in 1991. UNDP funds only accounted for 1.5% of new resources in 1992, an all-time low. The size of the Agency's UNDP programme cannot be determined by the Agency but depends on priorities the governments give to projects in the nuclear field within their country programmes for UNDP.

The overall implementation rate of 59.3% in 1992 was within the range prevailing over the past five years (from 56.5 to 67.8%).

Implementation by resource category

Resource category	Adjusted programme ($)	Share of total programme (%)	Net new obligations ($)	Implementation rate (%)
TACF	47 522 529	80.1	29 393 068	61.9
UNDP	1 270 164	2.1	620 102	48.8
Extrabudgetary	9 386 805	15.8	4 281 859	45.6
Funds-in-trust	1 157 753	2.0	899 291	77.7
Total	59 337 251	100.0	35 194 320	59.3

Programme delivery and support

During 1992, 1094 projects were operational. As 1992 was the second year of the biennial cycle, no new projects were introduced through approvals by the Board of Governors. During the year, 193 projects and 37 training courses were completed. The 1992 budgetary value of individual projects ranged from $9300 to $1.6 million. The Interim Project Implementation reporting system, which provided data on 305 of the projects ongoing in 1992, indicated that in 64% of the projects progress was rated "as planned or better". On 28% of the projects progress was rated "as planned", but additional action was recommended to remedy difficulties encountered. For 8% of the projects the indications were that progress was less than planned.

A total of 1009 months of expertise was provided through 2258 expert/lecturer assignments and 3837 months of training was given to 2154 persons through fellowships, scientific visits and training courses.

Technical co-operation programme delivery

	1988	1989	1990	1991	1992
Number of expert/lecturer assignments	2023	2144	2221	2306	2258
Number of expert/lecturer months served	1239	1246	1217	1160	1009
Number of expert/lecturer assignments undertaken by Agency staff	430	444	512	552	529
Number of purchase orders processed	3386	3894	3763	3772	3315
Number of fellows in the field	682	732	814	747	764
Number of visiting scientists	156	192	243	203	191
Number of participants in training courses	1109	1265	1358	1401	1199

The technical divisions of the Secretariat continue to play an indispensable role in supporting technical co-operation activities. One hundred and sixty five technical officers not only supported the ongoing projects, but also appraised the over 700 requests received for the 1993–1994 programme and evaluated over 850 fellowship applications. They also carried out 529 expert/lecturer assignments.

Distribution of technical co-operation activities by region and programme

While the share of the Asia and Pacific region in the assistance provided remained the largest (26.3%), it was below the previous five year average. In contrast, the share of Africa rose to 22.5%, well above this five year average.

In terms of the Agency's programmes (or fields of activity), safety related activities — consisting of projects in the fields of radioactive waste management, radiation protection and the safety of nuclear installations — accounted for 21.9% of the technical co-operation disbursements in 1992. Physical and chemical sciences — which includes such activities as the maintenance of nuclear instrumentation, of basic importance to developing countries which apply nuclear techniques — remained the single most important field of activity in the technical co-operation programme, with 19.8% of all 1992 disbursements. Food and agriculture followed closely, with 18.3%, human health accounted for 14.5% of all disbursements, followed by industry and earth sciences with 13%.

Technical co-operation activities carried out by area of activity

Area of activity	Number of technical officers	Number of projects supported	Number of fellowship applications evaluated	Number of expert/lecturer assignments	Number of months/ days
Food and agriculture	26	210	170	63	21/22
Human health	10	150	136	53	14/29
Physical and chemical sciences	22	329	170	90	26/08
Agency's Laboratory	16	54	77	36	13/06
Subtotal	74	743	553	242	76/05
Nuclear safety	41	184	151	148	34/26
Nuclear power	15	51	45	45	11/24
Nuclear fuel cycle and waste management	16	79	69	36	7/16
Scientific and technical information	6	11	9	6	1/07
Subtotal	78	325	274	235	55/13
Other	13	26	27	52	16/12
Total	165	1094	854	529	148/00

Assistance provided to various regions

Region	Overall share (%)						
	1987	1988	1989	1990	1991	Average, 1987–1991	1992
Africa	18.4	20.1	20.5	18.2	21.1	19.7	22.5
Asia and Pacific	30.0	29.0	29.6	31.9	29.8	30.1	26.3
Europe	18.9	13.8	13.4	16.3	14.4	15.4	15.2
Latin America	20.3	23.0	25.8	22.1	22.8	22.8	25.1
Middle East	2.1	3.0	2.1	2.4	2.8	2.5	2.8
Interregional	10.3	11.1	8.6	9.1	9.1	9.6	8.1

Note: Assistance provided on the basis of disbursement from all sources of funds.

Distribution of technical co-operation disbursements by programme and region

Programme	Inter-regional	Africa	Latin America	Asia and Pacific	Europe	Middle East	*Total*
Nuclear power	638.1	301.2	183.4	967.1	782.9	0.0	2 872.7
Nuclear fuel cycle	65.7	231.3	228.0	778.2	191.9	90.0	1 585.1
Radioactive waste management	181.5	182.2	249.8	456.2	423.9	0.0	1 493.6
Comparative assessment[a]	0.0	0.0	0.0	0.0	19.5	0.0	19.5
Food and agriculture	390.0	3 413.4	2 194.7	1 909.7	666.7	82.2	8 656.7
Human health	128.6	1 704.5	2 486.4	1 703.2	751.8	118.8	6 893.3
Industry and earth sciences	47.4	827.1	2 081.4	1 757.0	1 170.3	296.8	6 180.0
Physical and chemical sciences	612.1	2 486.5	2 596.8	2 235.6	1 206.0	253.6	9 390.6
Radiation protection	546.3	1 296.9	1 293.1	1 557.7	610.7	392.5	5 697.2
Safety of nuclear installations	500.8	182.6	310.0	832.8	1 380.2	0.0	3 206.4
Safeguards	0.0	0.0	0.0	16.9	0.0	0.0	16.9
Direction and support	736.4	28.0	287.6	260.5	16.1	79.3	1 407.9
Total	3 846.9	10 653.7	11 911.2	12 474.9	7 220.0	1 313.2	47 419.9

Note: All figures are in thousands of dollars

[a] The full title of this area of activity is: 'Comparative assessment of nuclear power and other energy sources'.

Evaluation

In spite of budgetary constraints, evaluation activities during 1992 followed closely the evaluation plan foreseen at the end of 1991. In addition to desk reviews, special emphasis was placed on the evaluation of large scale programmes and projects, such as a major programme evaluation of ARCAL, and the evaluation of manpower development projects in Africa. A fifth country evaluation was carried out covering the assessment of the impact of the Agency's technical co-operation activities in Chile.

Specialized service activities

Public information

Public information work was oriented to a significant extent to meeting the high level of media and public interest in the Agency's activities in Iraq under United Nations Security Council Resolution 687. Several TV networks produced documentaries on the Agency's work. Extensive Agency filming was made of four of the inspections. In addition, a booklet was published on the Agency's work in Iraq and the extent of Iraq's nuclear capabilities as determined by inspectors.

Media attention also focused on safeguards activities in a wider context, including those in the Middle East and East Asia.

Other issues attracting media coverage were the International Chernobyl Project, on which a 'broadsheet' was published, and the safety related work at nuclear power plants in central and eastern Europe.

The in-house video production capability was upgraded. Among new videos produced were those on the safety of industrial irradiation plants and "Radiation — a fact of life".

Five public information seminars were held — in Egypt, Hong Kong, Indonesia, Malaysia and Japan. The last of these was specifically designed for educators — a feature which will become a main focus of future seminars. A book entitled "Speaking of nuclear energy" and a report entitled "Nuclear energy: A balance of power" were published. Communications specialists from more than thirty Member States were brought together at a meeting that took place in September.

The Agency's quarterly journal, the *IAEA Bulletin*, and the bimonthly newsletter *Newsbriefs* provided topical material on issues such as nuclear power plant safety, the strengthening of safeguards and the non-proliferation regime, improvements in the management and control of radioactive material, and the role of nuclear energy in promoting sustainable development. The fourth edition of *Highlights* — a summary of the Annual Report — was produced.

The series of fact sheets which were issued for the information seminars and for wider distribution was expanded to include topics such as nuclear techniques in medicine and the Agency's emergency response capability. A booklet on employment prospects in the Agency was compiled for use in international recruitment efforts and induction courses for new staff.

INIS

Developments in INIS were targeted to increase the efficiency of the system's operations and the quality of services through increased use of innovative information technology.

INIS database

The WMO joined INIS in June, followed by Bolivia in October. This brought the number of participating international organizations to 17 and of Member States to 81.

A total of 88 990 records were added to the INIS database, bringing the total to 1 628 962 records. The quality control of the input submitted by the Member States has been strengthened by the expert system which was adapted to the changes made in both the subject scope and the categorization scheme.

In order to achieve more efficient and consistent indexing of the documents to be entered into the database, the personal computer software package FIBRE (Friendly Input of Bibliographic Records) was significantly enhanced and a new version distributed to 76 countries and international organizations.

In 1992, 75 INIS Liaison Officers received a free subscription to the INIS database on CD-ROM. These subscriptions contain archival and current disks and include future free updates. The INIS CD-ROM is available through a commercial distributor.

The total connect time for external users to the INIS database at the Agency was 243 hours for 1992.

The INIS Clearinghouse distributed about 490 000 microfiches, representing over 24 million printed pages of non-conventional literature documents, plus about 1.6 million printed pages of *INIS Atomindex*, which is available on microfiche. Thirty-two INIS members have standing orders for non-conventional literature microfiche services. By the end of 1992, the collection of documents available on microfiche exceeded 270 000.

A feasibility study on introducing optical disk technology for storage of the full text of non-conventional documents was started in November. This technology is considered an alternative to traditional microfiche production.

A meeting of INIS Liaison Officers was held in Rio de Janeiro. Recommendations were made concerning cuts in operating expenses, user needs, the training programme, printed products and other matters.

INIS database (cont.)

Shared support services

Library collections and services

The VIC Library focused its efforts on becoming a more service oriented organization and on streamlining its operations. A full range of information services continued to be offered to VIC staff, including the acquisition and circulation of library materials, the provision of reference and current awareness services, and on-line database searching. The user liaison programme was redefined, with library staff members assigned to each VIC organization to enhance communication with library users and responsiveness to their needs.

Financial constraints necessitated a comprehensive review and reduction in the journal collection, which was undertaken with extensive involvement of the Library's users. As a consequence, the Library increasingly relies on networking with other libraries to borrow materials for use by VIC staff. In 1992, the number of items borrowed in this manner exceeded 5000.

Computerization continued to increase operational efficiency. By August, the first milestone of the serials management system was completed for the check-in, routing and claiming of missing issues for all purchased journal subscriptions. In December, a year of evaluation and negotiation culminated in the signing of a contract for an on-line integrated library system that will eventually replace the current outmoded systems. Preparation for the conversion began with a complete inventory of the Library's collection, followed by updating of the collection database.

Computer services

At the end of the year, there were more than 1200 workstations of various types in the Agency. In accordance with the Agency's policy of decentralization, workstation users are being supported by staff in all Divisions and by the central computer services.

Two major applications using the new standard technology architecture went into effect in the second half of the year — an inventory system and a nuclear energy and facilities information system. The third major development was the redesigning and reprogramming of PRIS.

The Research Reactor Database (RRDB) was redeveloped for personal computers during the second half of the year, as were some other systems.

New courses were introduced to train staff in the new standard technology tools. Special courses were added for training administrators for Divisional networks. Especially important were the "basic skills" courses (DOS and Windows) that were provided without charge to ensure that all workstation users have a minimum of computer skills. Lunch-time tutoring in the Agency's standard word processing software, WordPerfect, was also added to the course plan.

A major emphasis in 1992 was the acquisition of the infrastructure upgrades approved by the Board of Governors in 1991. The new mainframe computers were installed in late 1991 and their operating system software was upgraded to the current standard, MVS/ESA, in March 1992. The response times and availability of both mainframe computers were excellent throughout the year.

During 1992, the first Departmental LANs were installed. Priority was given to replacing the obsolete Wang word processing equipment. This replacement was originally scheduled to be completed by 1995 but is now planned to be finished by the end of 1993.

Computer services (cont.)

The installation of additional telecommunications software and hardware in mid-year enabled the shared mainframe computer to participate in the Agency's LANs. It also defined the Agency as a major node within the international scientific INTERNET network which makes data available to Agency staff from computers in over one hundred countries. At the end of 1992, access to some Secretariat databases and internal electronic mail services was approved for the Vienna based missions.

The development of LAN standards and their implementation and management were a significant activity in 1992, and more resources are now being used for network services than for mainframe services. In addition, new vendors and new models of personal computers were evaluated. Over three hundred personal computers were ordered — many for upgrades to Agency standard models.

The Help Desk received approximately 5000 calls for assistance in 1992, ranging from reports of faulty equipment to requests for solutions to complex software problems. The implementation of one central contact point for the entire Agency, which is constantly staffed, has helped to streamline problem solving. In December, the first prototype of a call tracking system was installed to permit automatic logging and follow-up of calls for assistance.

Publishing

Over two hundred titles and journal issues were prepared for press and published. In addition to those listed or mentioned in other parts of the Annual Report, 1 book was published in Arabic, 12 in Chinese, 4 in French, 5 in Russian and 1 in Spanish.

Special publications issued in 1992 included "Nuclear Power, Nuclear Techniques and Sustainable Development" prepared for UNCED and "Report of the LASCAR Forum: Large Scale Reprocessing Plant Safeguards".

The set of new publications catalogues was completed for issue in early 1993.

Printing

The Common Printing Service continued to provide document and publications printing services for the Agency and also for UNIDO and the United Nations bodies based at the VIC. In 1992, the income from work for other organizations was around $1.81 million. The output of the Common Printing Service was 186 million page impressions, compared with 188 million in 1991.

STATISTICAL ANNEX

(All figures for the allocation and utilization of regular budget resources are given in United States dollars)

Implementation of project tasks in 1992 (numbers of tasks)

Programme	Planned			Status at end of year				
				Implemented		Postponed	Deferred	Cancelled
	Originally approved	Additional	Total	Fully	Partially			
NUCLEAR POWER AND THE FUEL CYCLE								
Nuclear power	86	8	94	56	18	4	14	2
Nuclear fuel cycle	54	6	60	40	8	0	5	7
Radioactive waste management	68	8	76	48	14	0	5	9
Comparative assessment of nuclear power and other energy sources	25	0	25	16	5	0	3	1
Programme — Total	233	22	255	160	45	4	27	19
NUCLEAR APPLICATIONS								
Food and agriculture	161	5	166	128	8	12	9	9
Human health	107	0	107	71	19	10	6	1
Industry and earth sciences	40	0	40	28	5	2	3	2
Physical and chemical sciences	95	9	104	68	10	6	17	3
Programme — Total	403	14	417	295	42	30	35	15
NUCLEAR SAFETY AND RADIATION PROTECTION								
Radiation protection	106	12	120	54	25	7	32	2
Safety of nuclear installations	131	18	149	70	29	9	26	15
Programme — Total	237	30	269	124	54	16	58	17
SAFEGUARDS								
Programme — Total	76	0	76	34	35	6	1	0
DIRECTION AND SUPPORT[a]								
Programme — Total	42	0	42	37	2	0	2	1
Agency programmes — Total	991	66	1057	650	178	56	123	52

[a] For the particular case of this programme, the combination of managerial, budgetary and service related activities does not lend itself to an approach that exactly follows the structure of the programme and budget document. Hence only overall programme totals are given.

Implementation of meetings in 1992 (numbers of meetings)

Programme	Total approved	Status at end of year			
		Held	Postponed	Deferred	Cancelled
NUCLEAR POWER AND THE FUEL CYCLE					
Nuclear power	38	27	3	7	1
Nuclear fuel cycle	22	10	0	4	8
Radioactive waste management	19	15	1	1	2
Comparative assessment of nuclear power and other energy sources	14	9	0	2	3
Programme — Total	93	61	4	14	14
NUCLEAR APPLICATIONS					
Food and agriculture	3	3	0	0	0
Human health	5	5	0	0	0
Industry and earth sciences	3	1	1	1	0
Physical and chemical sciences	13	10	1	2	0
Programme — Total	24	19	2	3	0
NUCLEAR SAFETY AND RADIATION PROTECTION					
Radiation protection	27	17	3	3	4
Safety of nuclear installations	46	29	2	6	9
Programme — Total	73	46	5	9	13
SAFEGUARDS					
Programme — Total	4	2	0	2	0
DIRECTION AND SUPPORT[a]					
Programme — Total	14	14	0	0	0
Agency programmes — Total	208	142	11	28	27

[a] For the particular case of this programme, the combination of managerial, budgetary and service related activities does not lend itself to an approach that exactly follows the structure of the programme and budget document. Hence only overall programme totals are given.

Allocation and utilization of regular budget resources for the nuclear power programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Nuclear power planning and implementation	NENP	1 376 600	1 208 400	1 160 876	185 600	30 124
Assessment and improvement of nuclear power plant performance	NENP	1 636 700	1 408 600	1 370 999	234 200	31 501
Improvement of reactor technologies	NENP	1 153 000	1 064 100	1 043 570	156 900	(47 470)
Development of advanced reactor systems	NENP	471 100	429 000	494 959	60 700	(84 559)
Nuclear fusion	NENP	77 600	60 600	50 634	0	26 966
	RIPC	598 900	517 200	491 764	0	107 136
	NESI	616 300	552 000	544 380	54 100	17 820
Subtotal:		1 292 800	1 129 800	1 086 778	54 100	151 922
Programme — Total		5 930 200	5 239 900	5 157 182	691 500	81 518

Allocation and utilization of regular budget resources for the nuclear fuel cycle programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Raw materials for reactor fuels	NENF	694 000	627 800	576 555	79 700	37 745
Reactor fuel technology and performance	NENF	919 200	776 200	742 210	36 800	140 190
Spent fuel management, technology and safety	NENF	1 045 600	869 000	844 059	115 900	85 641
Programme — Total		2 658 800	2 273 000	2 162 824	232 400	263 576

Allocation and utilization of regular budget resources for the radioactive waste management programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Handling, treatment, conditioning and storage of radioactive wastes	NENF	910 000	775 000	768 563	161 100	(19 663)
Radioactive waste disposal	NENF	651 400	537 800	542 001	10 600	98 799
Decontamination and decommissioning of nuclear installations	NENF	355 900	288 100	264 653	0	91 247
Radiological and environmental aspects of waste management	NENF IAEA-MEL	1 006 100 1 989 600	802 800 1 791 000	807 538 1 814 484	62 600 220 100	135 962 (44 984)
Waste management planning and infrastructure	NENF	562 600	518 500	539 974	33 600	(10 974)
Programme — Total		5 475 600	4 713 200	4 737 213	488 000	250 387

Allocation and utilization of regular budget resources for the subprogramme on the comparative assessment of nuclear power and other energy sources

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Comparative assessment of nuclear power and other energy sources	NENP	1 472 000	1 371 100	1 364 893	121 500	(14 393)
	NENF	183 200	151 100	134 588	0	48 612
	NENS	509 200	494 500	473 687	97 400	(61 887)
Subprogramme — Total		2 164 400	2 016 700	1 973 168	218 900	(27 668)

Allocation and utilization of regular budget resources for the food and agriculture programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Soil fertility, irrigation and crop production	RIFA RIAL	2 373 300	2 092 500	2 207 017	119 700	46 583
Plant breeding and genetics	RIFA RIAL	1 702 500	1 455 800	1 475 636	133 900	92 964
Animal production and health	RIFA RIAL	1 366 500	1 254 000	1 218 763	176 900	(29 163)
Insect and pest control	RIFA RIAL	2 276 500	1 990 300	1 840 805	122 800	312 895
Agrochemicals and residues	RIFA IAEA-MEL RIAL	1 363 300	1 193 200	1 237 059	15 600	110 641
Food irradiation	RIFA	857 900	712 900	715 917	52 100	89 883
Programme — Total		9 940 000	8 698 700	8 695 197	621 000	623 803

Allocation and utilization of regular budget resources for the human health programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Nuclear medicine	RILS	1 562 400	1 321 400	1 290 170	131 600	140 630
Applied radiation biology and radiotherapy	RILS	787 000	670 600	671 177	14 600	101 223
Dosimetry	RILS RIAL	1 321 100	1 126 300	1 196 682	94 600	29 818
Nutritional and health related environmental studies	RILS IAEA-MEL RIAL	1 629 500 391 400	1 388 700 344 900	1 308 637 315 317	22 900 0	297 963 76 083
Programme — Total		5 691 400	4 851 900	4 781 983	263 700	645 717

Allocation and utilization of regular budget resources for the industry and earth sciences programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Industrial applications	RIPC	857 000	662 700	652 476	82 700	121 824
Development of water resources	RIPC RIAL	2 377 400	2 070 900	2 068 976	80 200	228 224
Programme — Total		3 234 400	2 733 600	2 721 452	162 900	350 048

Allocation and utilization of regular budget resources for the physical and chemical sciences programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Nuclear and atomic data for applications	RIPC	2 617 500	2 471 400	2 438 774	473 600	(294 874)
Nuclear instrumentation	RIPC RIAL	1 622 900	1 414 700	1 392 246	98 100	132 554
Theoretical physics	ICTP	1 482 000	1 268 700	1 268 381	0	213 619
Utilization of research reactors and particle accelerators	RIPC RIAL	798 500	637 000	623 357	21 200	153 943
Chemistry	RIPC RIAL	1 627 800	1 349 800	1 297 851	455 500	(125 551)
Programme — Total		8 148 700	7 141 600	7 020 609	1 048 400	79 691

Allocation and utilization of regular budget resources for the radiation protection programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Basic radiation safety policy	NENS	797 600	759 900	757 154	135 300	(94 854)
Occupational radiation protection	NENS	1 104 800	862 300	848 243	256 100	457
Radiation protection of the public and the environment	NENS	700 100	606 300	600 003	102 900	(2 803)
Safe transport of radioactive materials	NENS	448 300	414 500	415 356	40 500	(7 556)
Emergency planning and preparedness	NENS	506 100	496 100	496 319	14 600	(4 819)
Control and safe use of radiation sources	NENS	719 000	608 500	606 271	168 000	(55 271)
Radiation safety services	NENS	460 900	459 900	467 112	0	(6 212)
Programme — Total		4 736 800	4 207 500	4 190 458	717 400	(171 058)

Allocation and utilization of regular budget resources for the safety of nuclear installations programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Basic nuclear safety principles and criteria	NENS	956 200	762 300	760 654	25 200	170 346
Safe siting and design of nuclear installations	NENS	725 200	583 800	586 684	139 200	(684)
Operational safety of nuclear power plants	NENS	732 900	622 800	622 101	57 900	52 899
Operational safety services to nuclear power plants	NENS	1 225 000	1 224 300	1 235 625	40 400	(51 025)
Management and mitigation of accidents in nuclear power plants	NENS	622 500	557 300	560 198	82 500	(20 198)
Research reactor safety	NENS	612 600	536 000	532 4350	66 000	14 150
Safety assessment of nuclear facilities	NENS	1 070 600	951 300	936 613	151 600	(17 613)
Programme — Total		5 945 000	5 237 800	5 234 325	562 800	147 875

Allocation and utilization of regular budget resources for the safeguards programme

Subprogramme	Responsible division	Approved budget (1)	Reduced budget (financial plan) (2)	Total expenditures 1992 (3)	Deferred programme (4)	Unused budget balance (1) - (3) - (4) (5)
Safeguards operations	SGOP SGDE SGIT RIAL	47 132 900	43 641 900	42 506 393	4 904 400	(277 893)
Support and development	SGOP SGDE SGIT SGCP	18 615 100	13 620 100	14 769 085	2 280 500	1 565 515
Safeguards management						
Planning, direction, co-ordination and control[a]	DDG-SG	[357 000]	[324 000]	[304 227]	[0]	[52 773]
Departmental services	SGSDS	2 138 000	1 785 000	1 785 534	14 500	337 966
Programme — Total		67 886 000	59 047 000	59 061 012	7 199 400	1 625 588

[a] Included in the direction and support programme.

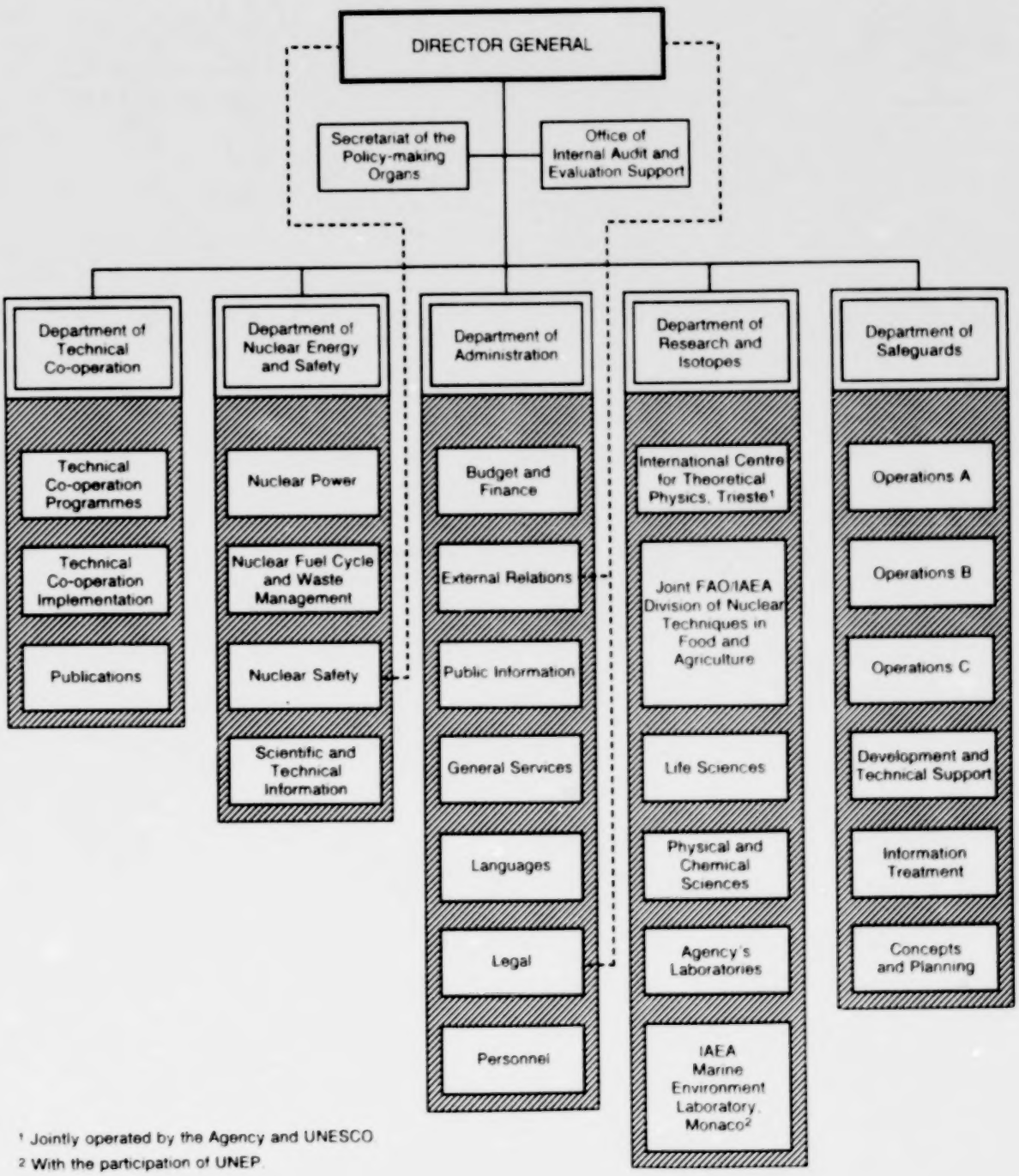
LIST OF ABBREVIATIONS

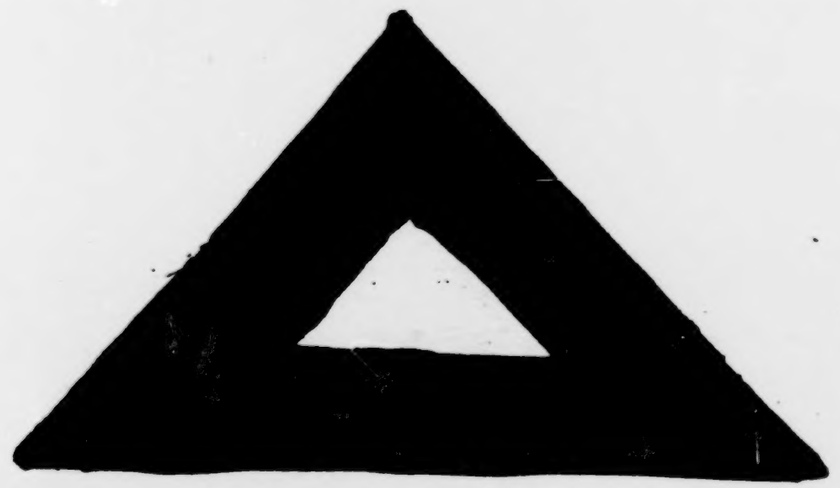
ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
BWR	Boiling water reactor
CANDU	Canadian deuterium-uranium (reactor)
CEC	Commission of the European Communities
CMEA	Council for Mutual Economic Assistance
CRP	Co-ordinated research programme
EEC	European Economic Community
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
FORATOM	Forum atomique européen
HTGR	High temperature gas cooled reactor
HWR	Heavy water reactor
IAEA-MEL	IAEA Marine Environment Laboratory
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
ICTP	International Centre for Theoretical Physics
IEA	International Energy Agency (OECD)
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organisation
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
INIS	International Nuclear Information System
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LMFBR	Liquid metal fast breeder reactor
LMFR	Liquid metal fast reactor
LWR	Light water reactor
MAED	Model for Analysis of Energy Demand
NDA	Non-destructive assay
NEA	Nuclear Energy Agency of the OECD
NENF	Division of Nuclear Fuel Cycle (IAEA)
NENP	Division of Nuclear Power (IAEA)
NENS	Division of Nuclear Safety (IAEA)
NESI	Division of Scientific and Technical Information (IAEA)
NUSS (programme)	The Agency's programme on nuclear safety standards for nuclear power plants
OAU	Organization for African Unity
OECD	Organisation for Economic Co-operation and Development
OLADE	Organización Latinoamericana de Energía
OPANAL	Organismo para la Proscripción de las Armas Nucleares en América Latina y el Caribe
OPEC	Organization of Petroleum Exporting Countries
PAHO	Pan American Health Organization/WHO
PHWR	Pressurized heavy water reactor
PRIS	Power Reactor Information System
PWR	Pressurized water reactor
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology

RIAL	Agency's Laboratory, Seibersdorf
RIFA	Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
RILS	Division of Life Sciences (IAEA)
RIPC	Division of Physical and Chemical Sciences (IAEA)
SG	Department of Safeguards (IAEA)
SGCP	Division of Concepts and Planning (Safeguards) (IAEA)
SGDE	Division of Development and Technical Support (Safeguards) (IAEA)
SGIT	Division of Safeguards Information Treatment (IAEA)
SGOP	Division of Operations (Safeguards) (IAEA)
SGSDS	Safeguards Departmental Services (IAEA)
SQ	Significant quantity
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNIPEDE	International Union of Producers and Distributors of Electrical Energy
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
VIC	Vienna International Centre
WANO	World Association of Nuclear Operators
WASP	Wien Automatic System Planning Package
WEC	World Energy Council
WHO	World Health Organization
WISE	World Information Service on Energy
WMO	World Meteorological Organization
WOCA	World outside centrally planned economies area
WWER	Water cooled and moderated reactor (former USSR)

ORGANIZATIONAL CHART

(as of 31 December 1992)



[1] Jointly operated by the Agency and UNESCO

[2] With the participation of UNEP